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GERMAN BUILDER CLAIMS THE FASTEST VESSEL AFLOAT—35.2 KNOTS.

Another claimant for the honors of the fastest vessel afloat has appeared in the famous German builder, F. Schichau, of Elbing, who has turned out a torpedo-boat destroyer with the astounding rate of speed of 35.2 knots. An account of this boat, together with a photograph taken at the maximum speed, are here reproduced from our German contemporary *Ueberall*. From the photograph one would hardly get the impression that the boat was traveling at such high speed, for there is but little noticeable change of trim and none of the "fuss and feathers" which generally marks high speed runs. In land miles the speed is equivalent to 40.55 miles an hour, or little less than many limited railroad trains. A translation of the article reads:

CHINESE TORPEDO-BOAT DESTROYER, WITH RECORD OF 35.2 KNOTS—LIGHT.

Since the appearance of the first torpedo boats, 20 years ago, the speed of this type of boat has been increased the rate of about a knot a year. The first small English torpedo boats did not make more than 15 knots, and to-day the latest torpedo-boat destroyers built in Germany have reached a speed of 35.2 knots. The foreign built boats of the same class built in 1898 on the contrary have barely exceeded 30 knots on their trial trips, with the exception of the English trial torpedo boat "Turbinia," built last year, which is said to have reached a speed of 32.75 knots. This boat is equipped with three steam turbines, each of which drives a shaft with three propellers, making a total of nine propellers. This great number of propellers is rather cumbersome, but the greatest disadvantage of the "Turbinia" lies in the fact of her inability to make any speed going astern.

The torpedo-boat destroyer shown above, photographed during its highest rate of speed, belongs to a series of four boats built for the Chinese Navy by F. Schichau, of Elbing, last summer. Each boat has twin triple-expansion engines, each driving one propeller. Fully equipped, and with 67 tons of coal on board, these Schichau torpedo-boat destroyers made a speed of 33.6 knots, which is one knot faster than the "Turbinia" when the latter was light, and the Schichau boats ran 35.2 knots when light, exceeding the speed of the "Turbinia" by 2 1-2 knots. The speed of 35.2 knots per hour represents a speed of 65.2 kilometers, and on the continent there are in Germany only eighteen, in Austria and France three each, and in Belgium only one express train which exceed this speed.

The latest results have demonstrated that the German builders have at last succeeded in outstripping all foreign competition in the construction of these speedy boats.

It will be some consolation to the navies of the civilized powers that these boats are for China. With Chinese crews and Chinese methods it is doubtful if the trial speeds will be attained in actual service.

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SLIP AND ITS RELATION TO THE PROBLEM OF SCREW PROPULSION.

BY EDMUND LEAVENWORTH.

(*Second and last Installment.*)

So far as there is any agreement among engineers and writers on this subject, the definition given in the concluding paragraph (c) of the first installment of this article (page 16, January, 1899, issue)—that given by an equality of developed thrusts—is the one implied in the use of the word *slip* as applied to a propeller working in a variable stream such as the wake.

INFLUENCE OF SLIP ON THE PERFORMANCE OF THE PROPELLER.

Having now shown what slip is, both in its simple and more complex aspects, let us proceed to a discussion of the influence of slip on the performance of the propeller.

We should now recall that the fundamental purpose of the propeller is to gain a propulsive thrust by giving to the water in which it works a sternward motion. Furthermore, the amount of such thrust will increase with the amount of water acted on, and with the change in its velocity. Hence, with the same amount of water acted on the greater the change or slip of the water the greater the thrust, and as the slip of the water and that of the propeller increase together, it follows that the greater the slip of the propeller the greater the thrust developed. This is illustrated in Fig. 1, which shows the nature of the relation between

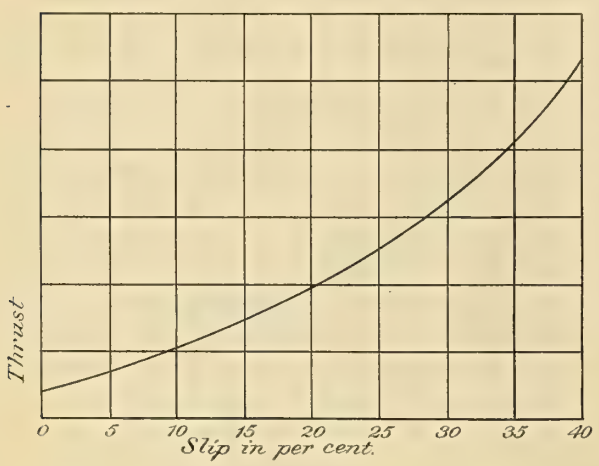


FIG. 1.

thrust and true slip, the speed being constant and the change in slip being produced by a change in revolutions; or again in Fig. 2, which shows the nature of the relation between thrust and true slip, the revolutions being constant and the change in slip being produced by a variation in speed. It thus appears that if a given thrust is desired it may be obtained by acting on a small amount of water with a large slip, or a large amount with a small slip, or by any intermediate combination of amount and slip which shall produce the necessary thrust. It follows further, since the amount of water acted on varies directly with the size of the propeller, that a given thrust may be obtained with a large propeller working at a low slip, or a small one at a high slip, or by intermediate combinations of size and slip as may be necessary to produce the thrust desired. The important point is to remember that size may be exchanged for slip and vice versa.

But the effect of slip on thrust is not the only influence with which we are concerned.

It is the duty of a propeller not only to develop a propulsive thrust, but to do so with the minimum expenditure of turning effort, and to drive the ship through the water with the minimum expenditure of

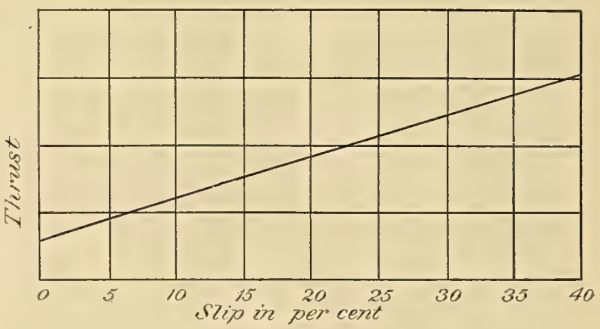


FIG. 2.

power in the engine. The question of *efficiency* is thus introduced. The idea fundamental in this term is a ratio of returns to investment. So far as the propeller is concerned, it is the ratio of the useful work (thrust multiplied by distance traveled) to the work absorbed by the propeller. The *distance traveled* may have two meanings, however, according as we consider the motion of the ship through the surrounding water, or that of the propeller through the wake. But, as already shown, these two speeds subtracted from the product $p\ N$ (pitch multiplied by revolutions) determine the two kinds of slip, *apparent* and *true*. It is, therefore, clear that the useful work and the efficiency will depend on the slip, and that there will be two kinds of efficiency, *apparent* and *true*, corresponding to the two kinds of slip. When not otherwise stated, the *true* slip and the corresponding *true* efficiency will, in the present article, be always understood.

The nature of the relation between slip and efficiency is shown graphically in Fig. 3. For A B the best efficiency is about 69 per cent, which is seen to occur at about 22 per cent slip, while for C D the same best value is found at about 20 per cent slip. These curves are characteristic of the relation between efficiency and slip. For low values of the slip the efficiency is very low, but increases rapidly as the slip increases, until a maximum value is reached, usually somewhere about 20 per cent slip. From this point the efficiency falls off more slowly as the slip increases, as shown by the curves from E to B and D. The causes of this complicated relation between slip and efficiency are beyond the limits of the present article. The important points are that the efficiency does

not necessarily increase with a decrease of slip, as is so often believed to be the case, and that very low values of the slip are not desirable because they will necessarily be accompanied by very low efficiencies. As another point deserving special attention, mention may be made of the fact that the efficiency varies but slowly when near its maximum value, and hence a moderate change in the slip may be allowed without seriously changing the efficiency. The slip might thus, for example, be considerably increased with a corresponding reduction in size of propeller and with a relatively small sacrifice in efficiency. It must not be forgotten, as before noted, that Figs. 1 - 3 and the accompanying remarks relate to the *true* slip, which is usually from 5 per cent to 15 per cent greater than the apparent.

NEGATIVE SLIP.

Perhaps no feature of the present subject has excited at one time and another more discussion than that of *negative slip*. This has been due in great measure to a lack of understanding of the phenomenon really in question, as well, doubtless, as to errors in data and measurement.

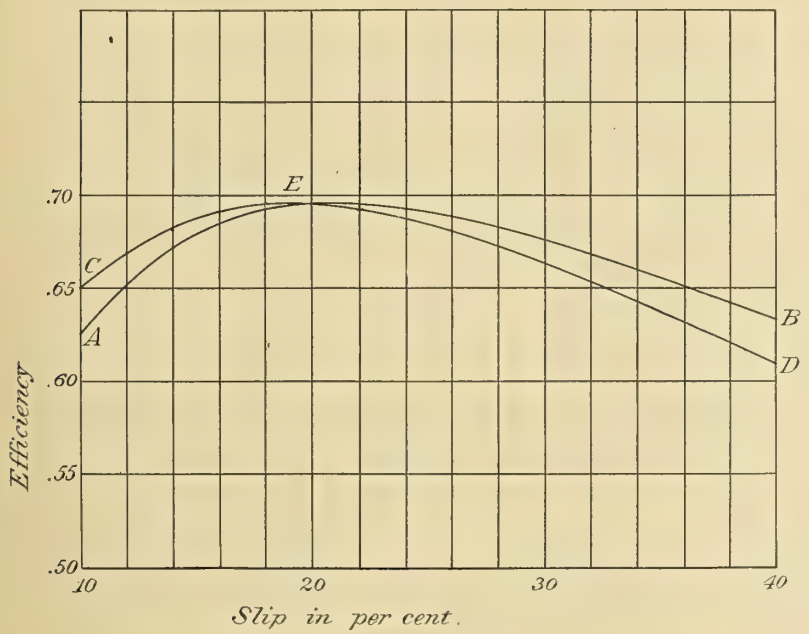


FIG. 3.

In the first place, it should be clearly understood that when reports of negative slip have been made, that it is the apparent and not the true slip which is in question. Failure to appreciate this lies at the root of most of the misunderstanding on the subject. The question is then simply, under what circumstances might we expect an apparent slip of zero or negative value? Remembering the relation between these quantities as expressed in (2) it may be readily seen that this will be the case when the true slip is equal to or less than the wake. If, therefore, the circumstances should be such that the true slip were quite small or the wake quite large, we might expect a negative apparent slip, not as anything remarkable or astonishing, but as a simple and natural result of the relations between the true slip and the wake. We have already seen that size of propeller and slip are mutually interchangeable, and in fact within limits a propeller may be designed to propel a given ship with any specified value of the true slip. If, therefore, the propeller is of appropriate diameter and revolutions, the true slip may be reduced to a small value such as 8 or 10 per cent, and with an ordinary value of the wake for single screw ships we should expect in such case a negative *apparent* slip.

As indicated by the curves of Fig. 3, however, the efficiency at such small values of the slip is very poor, so that it is always undesirable to work under these circumstances, and it may therefore be accepted as a general rule that a negative apparent slip always means a very inefficient performance.

Let it be understood, then, that negative slip always refers to apparent and not to true slip, and that there is nothing in the least mysterious or remarkable in the appearance of such a result under the proper circumstances. Again, there has often been great uncertainty in the proper measurement of pitch and in the determination of slip, especially in the case of propellers with variable pitch. As discussed in the foregoing, a mean may be taken in various ways, and there is no generally accepted method. Many cases of reported negative slip may be thus due in part or in whole to errors in measurement, or to the lack of a proper basis for the reduction of variable pitch to a mean value. Again, the influence of the rounded back on the performance of the blade, and especially on the question of its effective pitch, is a subject not yet worked out. But a full discussion of these phases of the question is beyond our present limits. It is enough to remember that, basing our ideas of pitch and slip simply on the geometrical measurement of the driving face, there is no reason under proper circumstances, as described here, why the apparent slip should not become zero or even negative in value. If it appears as an objection that the ship goes faster than the propeller, or that in some way the conservation of energy is violated, it should be clearly understood that negative apparent slip arises wholly from the existence of a wake, and that the performance is fully paid for at the engine and at a higher rate than would be the case were the slip greater in value.

The reason for the practical disappearance of negative slip under modern conditions is that propellers are rarely so large or so designed otherwise as to give the necessary thrust with a true slip as small as 8 or 10 per cent. Instead, such values as 20 to 25 or 30 per cent are more common, giving values of from 10 to 20 or 25 per cent for the apparent slip.

SPECIAL GOVERNMENT VESSELS—THE ARMY TRANSPORT "GRANT" AND SISTER SHIPS.

BY WILLIAM A. FAIRBURN.

Among the vessels secured by the War Department during the progress of the Hispano-American war for the transport of troops was the entire fleet of first-class ocean steamships of the intermediate type owned by the Atlantic Transport Line. These vessels were purchased outright, and at the close of hostilities, when the Government decided to retain a number of vessels in permanent service as transports, the former Atlantic liners were included among the vessels so selected.

The fleet purchased included seven modern steel vessels which had been in the London and New York trade. Of these, five are sister ships, viz., Mobile, Mohawk, Massachusetts, Manitoba and Minnewaska, and the other two smaller vessels are respectively named Mississippi and Michigan. These ships are comparatively new, and all were built at the yard of Harland & Wolff, at Belfast, Ireland. When the decision to retain the vessels permanently in service as transports was reached contracts were awarded to various shipbuilding firms for the rebuilding and refitting of the vessels of the Mobile class. Although the contract prices for this work vary from $83,000 to about $100,000, yet the total amount of work done on these vessels, including all machinery repairs and hull extras, cannot fall short of $130,000 per vessel. The Wm. Cramp & Sons Ship and Engine Building Company, of Philadelphia, Pa., have rebuilt the Mobile. The Bath Iron Works, Ltd., of Bath, Me., have completed the work on the Mohawk. J. N. Robins Co., of the Erie Basin Dry Docks, Brooklyn, N. Y., have repaired the Massachusetts, and the Newport News Shipbuilding and Dry Dock Company, of Newport News, Va., secured the order for rebuilding the Manitoba. The contract for refitting the Minnewaska at the time of writing has not been awarded. These five vessels being sister ships are practically all alike and all have been similarly refitted and rebuilt, so that a description of any one of the completed vessels will serve for all.

The service maintained by the Atlantic Transport Line with this fleet of steamers included passengers, cargo and live stock, and an extensive trade was also done in dressed beef, carried in refrigerating chambers. The passenger accommodation on each ship was very limited in extent, and there was only one class (cabin), each vessel having accommodation for fifty-two first class passengers in the bridge house amidships. In a few months a great change has been wrought in these vessels, and the not over-clean cattle steamers of the Atlantic Transport Line have now been converted into handsome, efficient transports, clean, staunch and pleasant to inspect and live on. And yet one must remember that a thorough cleaning and painting is responsible for a great deal of this change, and as cattle steamers these vessels of the Atlantic Transport Line were just as capable of battling with the elements and were just as efficient and successful in the work for which they were designed and built as they are now as United States transports.

GENERAL CHARACTERISTICS.

The principal dimensions of these vessels are:

Length over all	460 ft.
Length between perpendiculars	445 ft.
Beam	49 ft.
Moulded depth at side to spar deck	41 ft. 6 in.
Moulded depth at side to main deck	34 ft.

They are steel, spar-decked, twin-screw steamers with four decks, viz., spar, main, 'tween and orlop. As cattle steamers the spar deck was portable at the four main hatches and cargo ports. A bridge deck amidships was uncovered and served as the passengers' promenade deck; the chart house and bridge being at the forward end. The tonnage of these vessels while engaged in merchant service was:

Gross tonnage	5,780 tons.
Net tonnage	3,725 tons.
Under deck tonnage	5,285 tons.

At a draught of 26 ft. they carried a little over 7,200 tons dead weight, and their light draught, with water in boilers, steam up, but no cargo, coal, water or stores, was about 12 ft. 3 in. The freeboard assigned these vessels, measured from the statutory deck line, was: Summer freeboard, 8 ft.; Winter freeboard, 8 ft. 6 in.; Winter North Atlantic, 9 ft.; and in Fresh Water and Indian Summer, 7 ft. 6 in.

As transports their light draught is about 13 ft. and the displacement about 5,400 tons. When loaded to 15 ft. draught the displacement is 6,450 tons; at 20 ft. draught it is 9,000 tons; and at the extreme load draught of 26 ft. the displacement is about 12,200 tons.

These vessels have a double bottom extending from the forward collision bulkhead as far aft as is practicable, and there is also a trimming tank at each end of the vessel. The total capacity of the double bottom is 1,100 tons of water, and the total capacity of the two peak trimming tanks is about 125 tons. The double bottom is divided up into seven tanks, fore and aft, the two under the machinery carrying together 217 tons of fresh water. The three under the forward holds carry collectively 600 tons of sea water, and the two under the aft holds have a carrying capacity of 283 tons of sea water. Fresh water can now be carried in all the tanks of the double bottom. The holds of these vessels, i. e., all the space up to the orlop or lowest continuous deck, will be used for cargo, stores, coal and munitions of war, whichever the special circumstances demand. The capacity of these hold spaces is 149,000 cu. ft. The transports have also eight watertight complete transverse bulkheads, and therefore the hold spaces and all the 'tween-deck living spaces up to the main deck are divided into five watertight compartments. By means of watertight doors one can walk from the forward collision bulkhead to the after peak bulkhead on all the decks except the orlop, without any obstruction, provided the coal bunkers are not full. This may be a great convenience, but if any serious accident befall these vessels when loaded there is the possibility of this convenience leading to a most disastrous end. The troops are berthed on the 'tween and orlop decks; therefore these two decks are now known as the upper

and lower berthing decks. The main deck is designated the mess deck, and here, forward and aft, the soldiers will be fed, while 'midship the majority of the ship's complement will mess. The spar deck is the soldiers' weather or promenade deck, though considerable lounging will probably be done on the main or mess deck, as four large double and two single swinging side ports on each side of the ship—which will be always open in good weather—will make both the air and light on this deck very agreeable.

The cubical capacity of the orlop deck berthing space is 73,400 cu. ft., and that of the 'tween-deck berthing space 103,250 cu. ft. The store rooms and the magazine below the main deck have a capacity of 4,000 cu. ft., excluding all the refrigerating spaces. The cold storage rooms or refrigerating spaces are located just abaft the engine room on the orlop deck and on a flat below it. The capacity of these spaces is 32,250 cu. ft. Pulverized charcoal is used for the insulation of all these spaces.

These vessels had originally seven cargo hatches, excluding the meat hatch, but the aft hatch and the meat hatch have been closed up in rebuilding. There are now six hatches from the spar deck to the hold: No. 1 is about 10 ft. by 12 ft. 6 in., No. 2 is 21 ft. by 13 ft. 6 in., No. 3 is 15 ft. by 13 ft., No. 4 is 9 ft. by 10 ft., No. 5 is 14 ft. by 12 ft. and No. 6 is 12 ft. square. The first dimension in each case is the fore and aft dimension. Four of these hatches are forward of the bridge house and two are abaft it. A large double drum steam winch is located at each hatch. Large wooden portable booby hatches are placed on each hatch on the spar or weather deck. These boobies occupy in area on an average about one-half of the hatch space and from them two pairs of 48 in. portable stairs with rubber treads lead to the decks below. There is full head room in all of these booby hatches. Galvanized iron pipe railings are worked around all the hatches on the mess and berthing decks and similar railings are placed on all the stairs. The parts of the hatches on the spar deck not occupied by the boobies are fitted with the usual hatch covers and tarpaulins. Galvanized close-link chain (5-16 in.), with a suitable number of portable wrought iron stanchions, which slip over the hatch bar irons, form a satisfactory life line around the spar deck hatches when the boobies and hatch covers are removed for ventilation, etc. The booby hatches have been made portable and they are arranged so as to stow on the skid beams. A small booby hatch is located forward and a similar one aft, so as to give access to all the spaces below, when the stairs are all removed from the main hatches and the cargo is being taken on board.

Each vessel has four steel pole masts, all with a rake of 1 3-4 in. per foot. The trucks of the fore, main and mizzen masts are 142 ft. above the bottom of keel, while that of the jigger mast is 127 ft. There are in all twelve large cargo derricks or booms, the average size of these being 45 ft. long and 12 1-2 in. dia. The appliances for the rapid handling, loading and discharging of cargo are such as are found only on modern first-class money-earning vessels.

These transports have eleven boats and eight metallic life rafts each. Seven of the boats are 27 ft. life boats, with a beam of 8 ft. and a depth of 3 ft. 4 in. Two of the boats are 20 ft. working boats and the other two are 30 ft. steam launches, built by the Gas Engine and Power Company and Seabury Consolidated, of New York. Three of the 27 ft. life boats and the two 30 ft. launches are carried on heavy wooden skid beams above the spar deck. The remainder of the boats are carried on the hurricane deck amidship and the life rafts are carried on the top of the spar deck lavatory aft. Each vessel is fitted with three large wooden side ladders and eight rope Jacob's ladders with wooden treads, all of which lead from the weather deck to the high water line.

ACCOMMODATION OF SHIP'S COMPLEMENT.

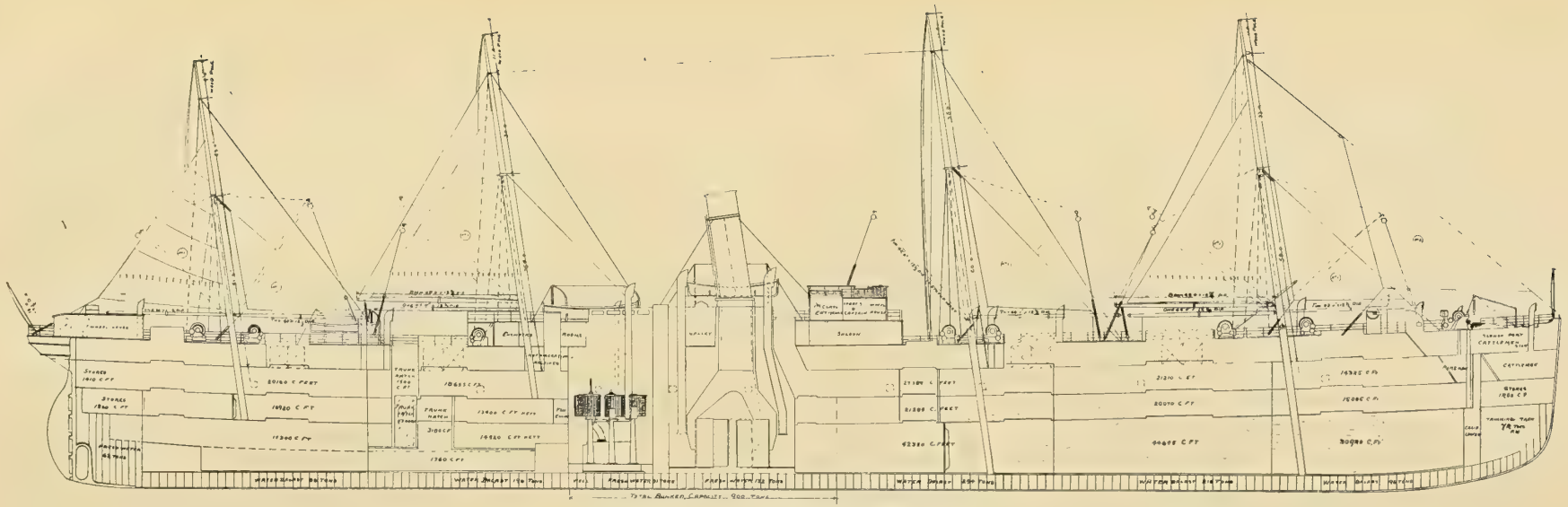
The seamen's quarters are located forward, there being a room on the main deck starboard side with eighteen berths and one on the 'tween deck at the extreme forward end with sixteen berths. The total number of berths for seamen is therefore thirty-four. The firemen and coal passers have a room on the main deck forward, port side, which contains fourteen berths, and also one on the 'tween deck just abaft the seamen's quarters containing twenty berths; the total number of firemen and coal passers' berths being thirty-four. All these rooms are airy, well lighted and commodious. The oilers and water tenders have a room on the main deck forward, starboard side, containing ten berths. A large room on the port side of this deck with twelve berths is used by the mess boys. Just forward of it is a room with six berths for the scullions. A room with four berths for the ship's quartermasters or wheelmen, and rooms with two berths each for the carpenters, boatswains and donkeymen, are located on the main deck, port side, between the scullions' room and the firemen's quarters.

The ship's officers' accommodation is located in the after part of the bridge house. Staterooms are here fitted for the first officer, second officer, third and fourth officers, steward, doctor, chief engineer, first assistant engineer, second and third engineers, fourth and fifth engineers, sixth engineer, electrician and refrigerating engineer, and two cooks, and a four-berth room is used by the bakers and assistant stewards. The officers' mess room is located on this deck just abaft the engine room casing. The captain's room is located alongside the chart house on the bridge deck forward, and the top of these two rooms forms part of the flying bridge which runs out to the side of the vessel.

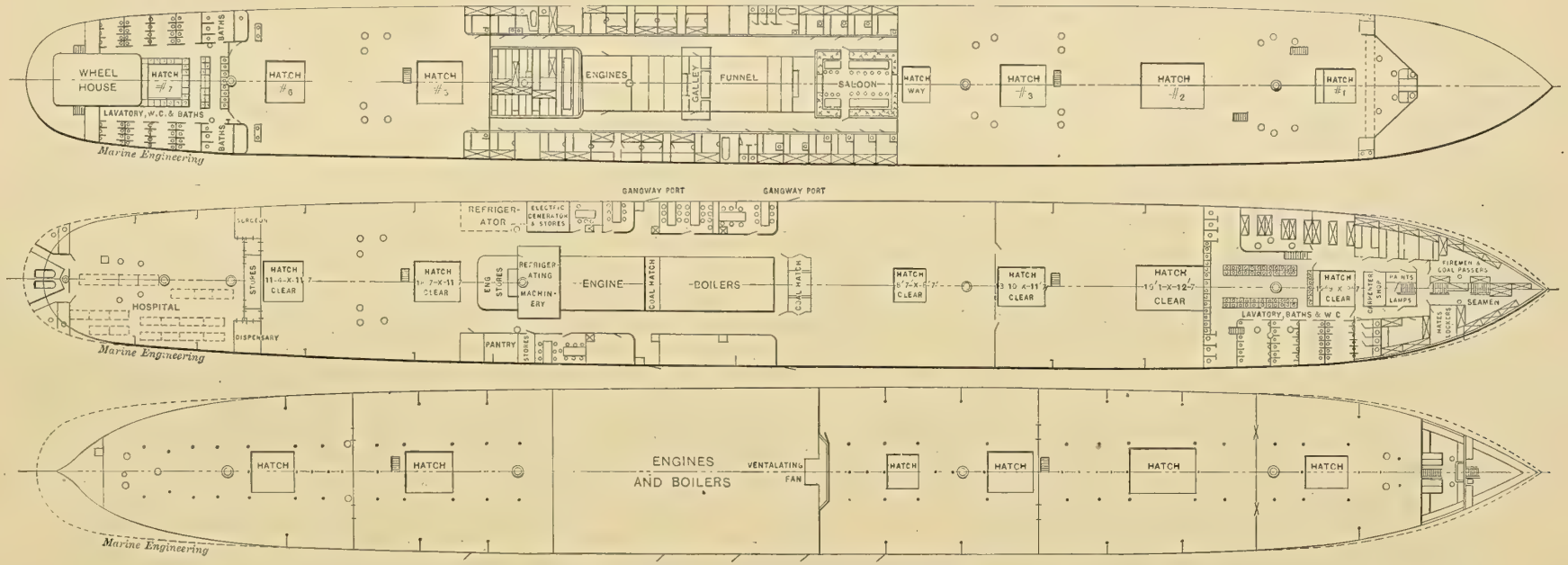
TROOPS' BERTHING ACCOMMODATION.

On the 'tween decks there are five compartments used for berthing the soldiers. Three are forward of the machinery space and two are abaft it. On the orlop deck there are only four compartments used for this purpose, as compartment No. 5 is part of the refrigerating space. The following figures give the number of berths in each space on the transport Mohawk:

The total number of berths on this vessel used for the accommodation of troops is therefore 2,118. This figure may vary a little from the other vessels, as the



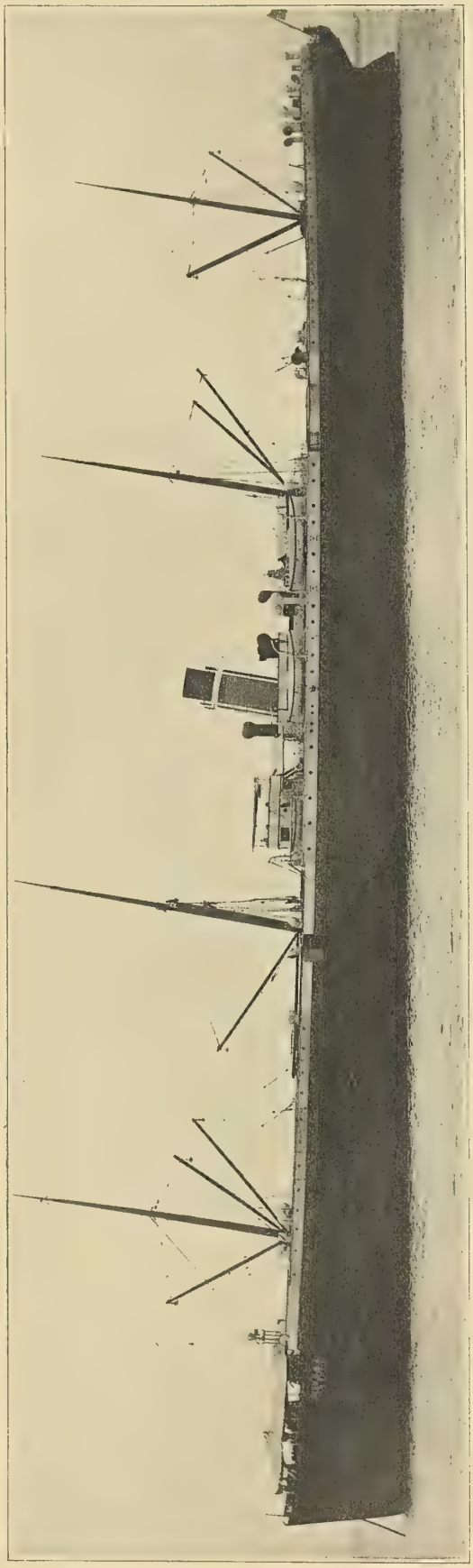
INBOARD PROFILE S.S. MOHAWK.



DECK PLANS TRANSPORT GRANT.

INBOARD PROFILE AND DECK PLANS OF THE U. S. TWIN-SCREW ARMY TRANSPORT GRANT, FORMERLY THE ATLANTIC TRANSPORT LINE S.S. MOHAWK.

UNITED STATES ARMY TRANSPORT GRANT, READY TO START FOR MANILA WITH THE 4TH AND 17TH U. S. INFANTRY ON BOARD.



ATLANTIC TRANSPORT LINER MANITOBA BEFORE RECONSTRUCTION AS A UNITED STATES ARMY TRANSPORT.—OTHER TRANSPORTS WERE SIMILAR IN APPEARANCE.

location of web frames is not the same on all these ships, and the Mobile has smaller berths than her sisters. The total number of berths on the Mobile is 2,136, but the larger berths, as fitted in the Mohawk, have been adopted as the standard. These berths are neatly made of galvanized pipe, three high. They are portable, and the stanchions fit into a flush socket in the deck—a brass fitting tapped into the deck from the under side—and into a hole in a heavy wood batten located on the deck above. The lowest berth is

No. of Compartment.	'Tween Deck.	Orlop Deck.
1	144	180
2	276	276
3	264	264
4	249	...
5	267	198
Total	1,200	918

about 8 in. above the deck and the others are 24 in. apart. The single berths are 77 in. by 25 in. centers. The double berths are 77 in. by 50 in. centers, and the double berths in way of stanchions are 53 in. wide. The decks are all steel in the troops' berthing spaces and they are not sheathed with wood, neither are they covered with linoleum. Wood gratings in the passage ways between the berths are being tried as an experiment, and if found satisfactory they will probably be adapted throughout. Some covering on the iron deck is absolutely essential for comfort, and cork, carpet, linoleum or wood should certainly be adopted.

REGIMENTAL OFFICERS' ACCOMMODATION.

There are twenty-four large, pleasant staterooms for regimental officers on the bridge deck in a new wooden house built around the engine and fire room hatches. There are also twenty-one roomy staterooms on the spar deck in the bridge house, which were formerly used for the accommodation of the passengers. All of these rooms have two berths each, a large, full-sized lounge or upholstered seat, washbowl and the usual stateroom furnishings and fittings. This makes berthing accommodation for ninety officers, and if the seats are used as berths sleeping accommodation can be provided for 137 regimental officers, for in two of the largest rooms the back of the seats will swing and form a berth. The quartermaster's office is in the forward part of the house on the bridge deck just abaft the captain's rooms; it contains desks, writing tables, bookcases, lockers, a large typewriter, copying press, etc. The quartermaster's stateroom and the rooms for his clerks are also located in this house, well furnished and complete in all their appointments.

TROOPS' MESS ACCOMMODATION.

The mess tables on the Mohawk—and her sister ships are fitted in a very similar manner—are of ash, 1 1-4 in. thick, with wrought iron legs and braces. They are 96 in. long and 27 in. wide. Each table has two ash benches, 18 in. high, 96 in. long and 10 in. wide. On the forward mess deck twenty-five tables are fitted, with a total seating capacity of 250 men. On the aft mess deck there are fifty-five tables, which will seat 550 men. The total number of mess tables is therefore eighty, and the total seating accommodation is for 800 men. These mess tables stow in bails overhead between the beams and in racks on the bulkheads.

REGIMENTAL OFFICERS' DINING SALOON.

The regimental officers use the old ship's cabin or main saloon as their dining room. In this saloon there is seating accommodation for about forty-eight people, but the tables are arranged differently on the different vessels. This room is elegantly furnished. A piano is located at the aft end, and the room has been practically unchanged, the upholstering and furnishings being the same as they were when the room was used for the accommodation of cabin passengers in the transatlantic trade.

MESS ROOMS FOR THE SHIP'S COMPLEMENT.

The ship's officers' mess room is in the after part of the bridge house, but all the petty officers and crew mess in rooms on the main deck amidship abreast the machinery casing. The forward mess room on the port side is for the seamen. Here there are two tables and twelve stools. Aft of this room is the firemen and coal passers' mess room, with three tables and sixteen stools. Then comes the petty officers' mess room, with one table and six stools, and aft of all is the oilers and water tenders' mess room, with one table and six stools. On the starboard side is the stewards' mess room, with two tables and thirteen stools. The total number of tables in the rooms on the mess deck 'midship for the ship's complement is therefore nine, and the seating capacity is fifty-three men.

HOSPITAL BAY.

The hospital bay is located on the main deck aft. It extends from the aft mess space to the extreme aft end of the ship. About thirty double beds are located in the hospital, which is 57 ft. long and 38 ft. wide. In the lazarette are bath rooms and water closets, opening from the hospital, and at the forward end is the dispensary, doctor's office, kitchen and store room, and two nurses' rooms. The floor of this room is covered with cork carpet, and the hospital is well lighted and ventilated, a large trunk hatch, 10 ft. square, fitted with a skylight on top, leading from the deck above.

LAVATORIES, WATER CLOSETS AND BATH ROOMS.

One of the most important features of a successful transport is the fitting of an adequate number of wash bowls and water closets. In these vessels this essential has been given great thought, and the result is most gratifying. A large lavatory is fitted forward, between the crew's quarters and the soldiers' forward mess room on the main deck. The floor is covered with asphaltum and cement panels, and here thirty water closets with flushometer valves, fifteen urinals, six shower baths and sixty-one wash bowls are located to good advantage. The aft lavatory is on the spar deck, just forward of the wheel house. This is fitted in a similar manner to the forward lavatory, and in it are located twenty-eight water closets, thirty urinals, thirty-three wash bowls and eight shower baths, two of the latter being in separate rooms for the offi-

cers. Other water closets, tub baths and wash bowls are located throughout the vessel where most desirable. Large mirrors are placed over all the wash bowls in both lavatories, and these rooms have a rich, expensive appearance quite different from what one would expect on board an army transport.

GALLIES AND PANTRIES.

The coal galley on these vessels is about 21 ft. by 8 ft. 6 in. It is fitted complete with ovens and ranges of ample capacity. The steam galley is a very large, commodious room on the main deck, starboard side, amidship. It is 35 ft. long and 9 ft. wide, and is fitted with eight large kettles and two urns. A scullery about 14 ft. long and 9 ft. wide is fitted just aft of the steam galley, and a large pantry with about 100 sq. ft.

VENTILATION.

Each vessel is fitted with a very complete ventilating system. Four large steam fans are located on the spar deck. Air heaters, coolers and cleansers are provided. Galvanized iron ducts rectangular in section deliver air to all spaces occupied by troops, hospital, gallies, saloon, pantries, mess rooms, forecastle and all sleeping rooms except those on the bridge deck.

ELECTRIC PLANT, ETC.

The vessels are beautifully illuminated, and at night the living spaces are as light as day. Each vessel has 600 16 C. P. electric lights. The old British electric generators have been rewound for 110 volts, and the vessels have been rewired throughout and converted

U. S. TRANSPORT GRANT—SHOWING TRIPLE-TIER BERTHING ARRANGEMENTS.

of floor space is fitted just aft of the main saloon or officers' dining saloon. This pantry is fitted with an 8 ft. steam table, two urns, dressers, ice box, etc. In the hospital kitchen aft there are two cereal cookers, a 5 ft. steam table and two urns. A small room opens from the ship's officers' mess room, for washing dishes, and a room is used for a similar purpose just abaft the saloon pantry. A large bakery is located in the bridge house on the port side amidship, well equipped with bins, lockers and an electric kneading machine. Each vessel has large linen and store rooms for the steward's department.

to the double wire system. A new dynamo and engine has been furnished by the U. S. Government, and this is located in a new electric generating and store room on the main deck port side amidship. A search light has been placed on a platform built above the bridge forward. All the spaces below the weather deck are painted white. A first class distilling plant has been fitted, and large tanks with brine coils are provided for troops' cold, fresh drinking water.

FITTINGS IN GENERAL.

Awnings of No. 4 cotton duck have been provided to

cover the entire length of the ship. These awnings are placed about 4 ft. above the hurricane deck and also over the skid beams.

The outfit of these vessels, boats, rafts, life preservers, buckets, also fire connections, hose, etc., are supposed to cover all the requirements of the U. S. steamboat inspection rules for passenger ships.

Musket racks are fitted in all the troops' berthing spaces, with a total capacity equal to the number of berths. These racks have a locking device, and they are placed above a rectangular air duct at the sides of the vessel.

PROPELLING MACHINERY.

The propelling machinery of these vessels is of the usual type fitted in vessels of this class at the time these vessels were constructed. The total length occupied by the machinery is 80 ft., and of this space 25 ft. is devoted to the engine room. Aft of the engine room is a recess 10 ft. long and about 8 ft. high and the width of the engine room, in which the thrust bearings and two old dynamos are located.

Each vessel is propelled by twin screws with triple-expansion engines and three cylinders, each working on its own crank. The cylinders are not directly connected to each other, and the high pressure is located forward and the low pressure aft. The cylinders are 22 1-2 in., 36 1-2 in. and 60 in. dia., with a stroke of 48 in. The piston-rods of the intermediate and low-pressure cylinders extend up through the cylinder head and form tail rods. The high pressure cylinder has a piston valve, and the others are fitted with slide valves.

The hull of the vessel is built out to the shaft struts aft.

Steam is supplied by two double-ended and two single-ended Scotch boilers at 175 lb. working pressure. On their trial trips in the light condition these vessels are reported to have attained a speed of 13 to 13 3-4 knots per hour, but at the present time in actual service the speed of these vessels will vary from 10 knots loaded to about 12 knots light. The piston speed is very low, the maximum being only about 550 ft., and at this speed the two engines together will indicate about 3,000 I. H. P. In actual service 60 revolutions and 480 ft. piston speed is all that can be obtained. The auxiliaries on these ships are so numerous, and such great steam consumers, that fully one-fifth of the boiler power will at times be required for the auxiliaries. The coal bunker capacity is 900 tons, and the vessels burn about 60 tons of coal per day at full speed.

The machinery of all of these vessels is not in first-class condition, but probably all the defects will in time be remedied, and careful management and running will prevent a repetition of the condition of affairs which existed at the time these vessels were sent to private shipbuilding yards to be rebuilt and refitted.

The War Department has recently decided to name these vessels after famous generals, and the "Mohawk" will now be known as the "Grant," the "Mobile" will be called the "Sherman," the "Massachusetts" will be renamed the "Sheridan," and the "Manitoba" and "Minnewaska" will probably be called the "Logan" and "Thomas" respectively.

AN INLAND SHIPYARD.—SITUATED ON THE JAMES RIVER AT RICHMOND, VA.

Nearly three hundred years ago Captain Christopher Newport, under orders from the London Company, sailed up the James river as far as Richmond, and there located, as the old chronicle has it, safe from the Spaniards. A few months ago, at the outbreak of the war, the Government had under consideration the building of ten gunboats, at the same place, to be safe from the same Spaniards. Thus the verdict of the centuries points to Richmond as a place inaccessible to a hostile sea force; and as for a land force, the difficulties of investing that city are well known.

The place is well situated for a shipyard; the James river has a depth sufficient, at present, for boats drawing 18 ft. of water, and the Government has commenced deepening it; eventually there will be 22 ft. at low and 25 1-2 ft. at high water, enough to float anything but the largest ships.

The torpedo boats now under construction are not the first efforts of Richmond in the direction of ship building. The Tredegar Iron Works, famous for its cannon, built vessels for the U. S. Navy before the war, and during the war several gunboats were built. At the time of the evacuation of the city the last gunboat fell into the hands of the Federal forces; it had been named the *Ladies' Gunboat*, and was built wholly from contributions of plate and jewelry given by the Southern women. After the war the Old Dominion Steamship Company built one ship there.

Modern marine work in Richmond dates from the construction of the engines of the U. S. battleship Texas by the Richmond Locomotive Works, under the supervision of William R. Trigg, who was president of the company at that time.

The magnitude of the undertaking attracted widespread attention, and the success of the engines was so great as to demonstrate once for all that the mechanical ability of the American people south of Mason and Dixon's line was equal to that of their brothers in the North.

The attention of the Government has been turned more than once toward Richmond as a place for building warships. In critical periods of the country's history, especially at the time of the Venezuelan trouble, its securely protected harbor and abundance of water, with free connection to the sea, were advantages that appealed directly to the understanding of members of the Government, and arrangements were actually in hand for the rapid construction of small gunboats.

The plan of the yard now in operation at Richmond has been matured, step by step, during many months, although to the people at large the yard's entrance into the torpedo boat competition was very unexpected and occasioned considerable surprise and discussion in shipbuilding circles.

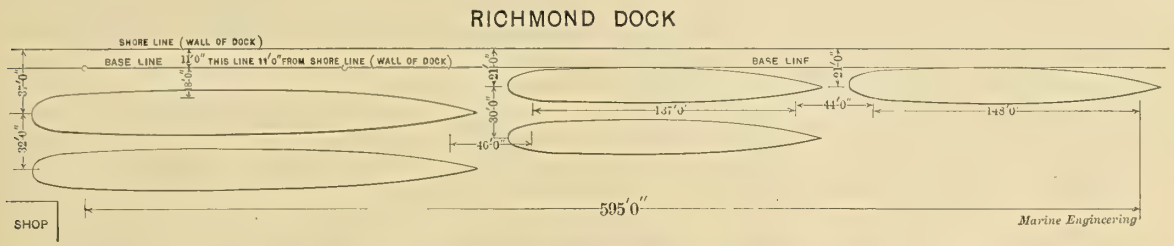
The plant of the William R. Trigg Co. will eventually be very complete. With about 1,000 ft. of water front, it can handle almost any class of ship excepting the largest, and is also prepared to do, and will

do, the best possible class of work. Eventually the falls of the James river are to be utilized for the generation of electricity, somewhat after the plan of the Niagara Falls Power Company, and as soon as this is completed the Trigg Company will use the power thus obtained, as is now done in the shipyard in Buffalo, N. Y.

The shipyard has a complete outfit of angle and plate tools, embodying the latest designs, fitted by

After the torpedo boats are well under way the company will devote some attention to merchant work, but at present it does not care to undertake any but Government work, so that the present contracts will be finished on time.

The boats are to be launched sideways, as is the custom in river launching. The accompanying plan shows the general arrangement of the boats on the stocks. When the works are running under full load



LOCATION OF WAYS FOR TORPEDO BOATS IN TRIGG YARD.

the Hillis & Jones Co., of Wilmington, Del. The Chicago Pneumatic Tool Company has contracted to furnish all the necessary pneumatic tools for riveting,

they will have about 500 men on the pay roll.

At the time that William R. Trigg submitted bids in his own name for these boats there was consider-

VIEWS IN THE NEW TRIGG SHIPYARD AT RICHMOND, VA.

drilling and caulking, and will shortly have the plant in complete working order.

The machine shop is 375 ft. long by 100 ft. wide, with a large L, and is fitted with all the necessary tools, including many new ones from the best makers.

The brass foundry, pattern and cabinet shop and smith shop are well fitted to meet the sharpest competition.

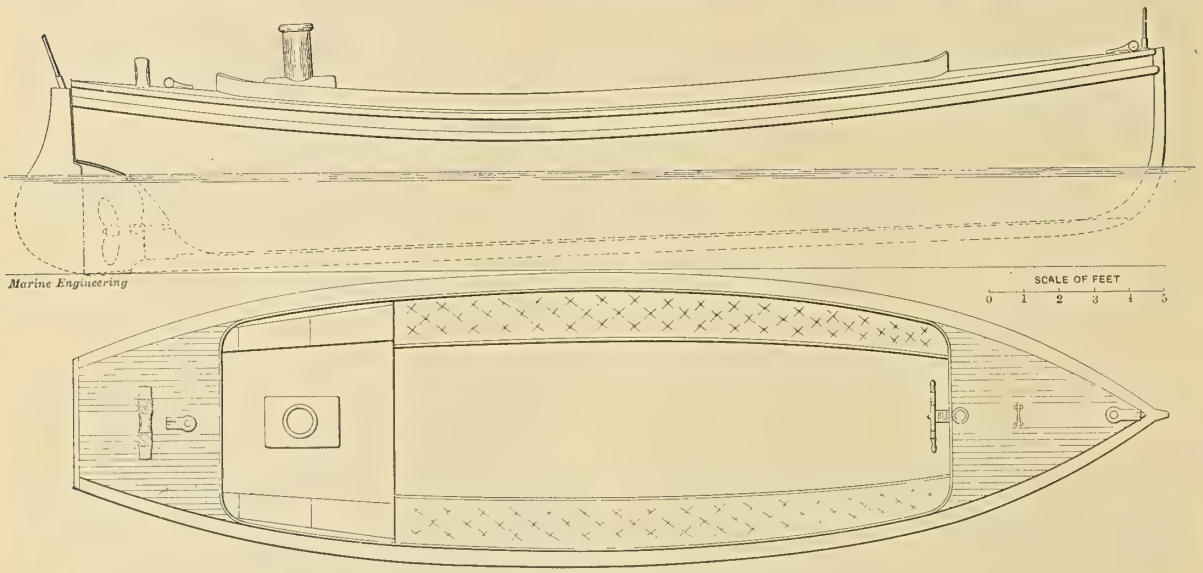
able opposition from the other builders, but the showing that he made in a few weeks convinced the Navy Department that the Trigg Company could fulfil its obligations, and its showing up to the present time, although working under the disadvantage of establishing a new yard, is such as to place it on a plane with older competitors.

The accompanying photographs show the present

condition of the yard, and the energy with which this work has been conducted, as two months ago the space now occupied by the ship shed was a junk heap of old rails and ties.

William R. Trigg, the president, is aided by Lilburn T. Myers, vice-president. The superintending naval engineer, William Strother Smith, U. S. N., and the naval constructor, George H. Rock, U. S. N., are in charge of the Government end of the work.

The company is building three torpedo boats, the Shubrick, Stockton and Thornton, and the two torpedo-boat destroyers Dale and Decatur. The torpedo boats are 175 ft. long, and are to make a speed of 26 knots at 165 tons displacement with 3,000 I. H. P. The destroyers are 245 ft. long, and must make a speed of 28 knots at a displacement of about 400 tons with 8,000 I. H. P. The contract prices are $129,750 and $260,000, respectively. The destroyers are to be finished in eighteen months and the torpedo boats in twelve months from the date of the signing of the contract.



OUTLINES OF MOTOR BOATS FOR S.S. PARIS OF AMERICAN LINE.

Motor Boats for S.S. Paris.

As part of the equipment of the steamship Paris, of the American Line, when she leaves on a cruise to the West Indies, two alco-vapor launches will be carried. The design of these boats is shown in the accompanying engraving. As they are both alike the description of one will serve for the two.

The dimensions are: Length, 30 ft.; beam, 8 ft. The specifications call for a keel of white oak, sided, 3 in.; moulded at fore end 4 in., at stern 6 in.; stem of white oak, sided 3 in.; apron and deadwoods of white oak; stern post and overhang of quartered white oak; post sided 4 in.; timbers of white oak, spaced 11 in. centers, steam bent, sided 1 1-4 in.; moulded at head 1 1-2 in., at heel 2 1-2 in.; floor timbers moulded 3 in. at seat, sided 1 1-4 in.; keelson of oak, 3 in. by 3 in., copper bolted through keel; clamps of oak, 2 in. by 4 in., running entire length of hull and riveted through sheer strake, two on each side; planking of white cedar, to finish 3-4 in.; covering board and sheer strake of quartered oak; decking, 7-8 in. quartered oak, laid in 2 in. strips; 2 in. guard rail on lower edge of sheer-strake.

The boats will have open seats, and lockers will be provided in the motor room. A 12 horse power alco-vapor motor will be fitted and tank capacity for two barrels. A double tow post aft with crosshead will give facilities for towing the ordinary ship's boats for landing parties. Galvanized iron stanchions (2 in.) will be fitted fore and aft, with eyes in the heads, to go through the deck and step in the deadwood, and the deck plates for these will have screw caps to go in place when the stanchions are out. The fittings will include a steering wheel and chain gear, chocks and cleats, flag poles and sockets, strong hoisting eyes. A power whistle and kit of tools will also be provided. The hull will be finished with three coats of white paint, and the sheer strake, decks and inside of cockpit will be finished in natural color and given three coats of spar varnish.

The new steamship Hamilton, for the Old Dominion Line, recently launched at the Roach yard in Chester, is a sister ship to the Princess Anne, described in our issue of August, 1897. Her dimensions are: Length, 332 ft.; beam, 42 ft.; depth, 27 ft.; tonnage, 3,200 tons. She is a single-screw vessel, and will be fitted with triple-expansion engines having cylinders 28 in., 44 in. and 73 in. dia. by 54 in. stroke. She will have three decks and four water-tight bulkheads, and will have accommodation for about 120 first-class passengers.

An order is reported placed by the Boston Tow Boat Co. with the Sparrows Point (Md.) yard for two steel colliers, each of about 5,000 tons capacity. The dimensions given are: Length, 345 ft.; beam, 47 ft.; depth, 28 ft. They will be fitted with triple-expansion engines and Scotch boilers.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—II.*

BY R. W. JACK.

It has been accepted by many engineers, I think wrongly, that there are different qualities of steam, and in many of our text books those qualities are spoken of as the words imply, viz., saturated steam, dry saturated steam, superheated steam, etc. It would appear that the only object aimed at is that an expression may be found for an otherwise unaccountable percentage of water which interferes in our calculations. The terms are vague in the extreme, for if we admit that each appellation has a separate significance, there would be no limit to their number, because it may further be said that steam may contain water in suspension from only a trace up to a considerable proportion. It is at least much simpler and better adapted to our purpose to say that there is only one quality of steam, or rather that there is only one term which we can consistently employ, viz., pure steam.

Steam, then, free from water or other impurity, and without undergoing a superheating process, is possessed of three distinct properties—pressure, volume, and temperature. One cannot change without affecting the other two. Each succeeding pressure has its corresponding volume and temperature; for instance, steam at a gauge pressure of 150 lb. per square inch has an invariable temperature of 370° F., and a specific volume of 173 compared with an equal weight of water. It will thus be seen that, given the pressure of steam at any point on an indicator diagram after cut-off or before exhaust opens, we may easily compute the volume and thereby the amount of water represented by the steam admitted to the cylinder for one stroke. The expansion curve becomes a most interesting study in this respect, for the steam line is influenced to some extent by the valve motion, by the rate of flow or the area of steam ports, and the temperature of piston and body of the cylinder. After cut-off has taken place, the steam which may have been condensed on entering will probably in part regain at some point its gaseous properties, and the equivalent weight of water will become a maximum. For the sake of simplicity, we are bound to suppose at this point that the engine is in good repair, that the valve and cylinder faces are steam tight, and that the piston is efficient for its purpose.

To find the maximum amount of water accounted for by the diagram, take the following specific example: Fig. 7 is a diagram taken from a high pressure engine whose cylinder is 3 in. diameter by 39 in. length of stroke. Take points x and y on each diagram just before exhaust opens. Those points, as a rule, will indicate the greatest quantity of steam since the water of condensation may possibly have reappeared as steam. Ascertain the pressures at x and y to scale, and also measure the portion of stroke completed at those points, say 35 in. The total volume of steam is therefore $= D^2 \times .7854 \times$ part of stroke completed + the clearance capacity at the end of the stroke. Let the clearance be 10 per cent of the space swept by the piston or $(D^2 \times .7854 \times \text{stroke}) \div 10$. We then have

Total volume of steam

$$= (23 \times 23 \times \cdot 7854 \times 35) + \left(\frac{23 \times 23 \times .7854 \times 39}{10}\right)$$

Worked out, this is shown to be 16162.27 cu. in. The pressure of steam at the point x is 110 lb. per square inch. By looking up a table of specific volumes we find that one unit of steam at this pressure, if condensed to water of the same temperature, occupies only $\frac{1}{220}$ of its previous volume. We must therefore divide the total volume of steam 16162.27 by 220 in order to find the equivalent volume of water, thus 16162.27 ÷ 220 = 73.46 cu. in., nearly. The opposite diagram is treated in the same way. Those

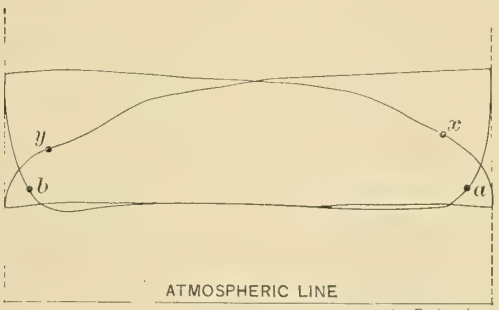


FIG. 7

operations may be further extended to either the I P or L P cylinders of a triple-expansion engine, and the deductions therefrom will scarcely require further explanation; but it should be pointed out that if we wish to find the quantity of water per revolution, per minute, or per horse power, it will be necessary to deduct from the foregoing result the weight of steam remaining in the cylinder after exhaust closes and compression begins. Points a and b may be taken in the same way on the compression curve, the steam at this pressure and volume correspondingly reduced to water and subtracted. The capacity of waste space at each end of cylinder we have supposed to be one-tenth of the space swept by the piston, which we found to be equal to 1620.36 cu. in., and the points a and b are taken in this case at 2 in. from the end of stroke, so that the total volume of steam remaining at pressures indicated by a and b is $1620.36 + (D^2 \times .7854 \times 2) = 1620.36 + 831 = 2451.36$ cu. in. The pressure of steam at the point a we find to be 100 lb. per square inch. Referring again to the table of specific volumes, we find that the relative volume of water is $\frac{1}{236}$, so that the equivalent volume of water remaining in the cylinder is $= \frac{2451.36}{236} = 10.4$ cu. in. nearly. Subtracting this from the first result we have 73.46—10.4 = 63.06 cu. in. of water utilized each down stroke of the piston. The same operation is performed for the return or up-stroke, and their sum is the amount of water passing through the cylinder in the form of steam during each revolution.

To find the quantity of water accounted for by diagrams per minute or per hour, it is only necessary to multiply by the revolutions in the given time. The

* From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

water used per I. H. P. per hour is equal to the total quantity per hour divided by the total I. H. P. If the weight of water be required, this again should be multiplied by .036, the weight of one cubic inch of water. We might also find the amount of work in foot-pounds, transmitted by each pound of steam, by dividing (I. H. P. × 33,000) by the weight of steam passing through the engines per minute. In the case we have considered, the combined I. H. P. of the three engines was 1,130, and the water shown by the H. P. diagram and per minute is 265.68 lb., then (1,130 × 33,000) ÷ 265.68 = 140,356 foot-pounds or units of work per pound weight of steam.

It has been attempted by various thermodynamists to obtain a modified equation which shall consider certain relations which are specially applicable to steam. Their calculations, however useful, have been based on assumptions which cannot possibly obtain in practice. They have supposed an ideal environment for the steam, such that it is incapable either of receiving of transmitting any portion of heat. This they have designated "adiabatic" expansion (literally meaning—nothing passing through), that is to say, the steam can neither impart its heat to its surroundings nor receive heat from any external source; but their calculations have taken into account those properties of steam which are strictly characteristic of such a medium. Stated shortly, it may be said that if a gas at a given volume, pressure, and temperature, by an addition or subtraction of dt of temperature could add or subtract equal increment of the volume and pressure, then $\frac{dv}{v}$ would be equal to $\frac{dp}{p}$. It requires more heat to add to volume at constant pressure than it does to add to pressure at constant volume, because in expanding at constant pressure an amount of external work is done requiring a certain amount of heat. The proportion of heat required is thus:

Heat required at constant pressure : heat required at constant volume :: Kp : Kv. But the specific heats at constant pressure (Kp) of gaseous bodies are known from direct experiment, and the specific heats at constant volume (Kv) may be calculated from Kp by deducting the thermodynamical equivalent of the work performed by the gas in doubling its volume. The increment of volume will therefore be less than the increment of pressure for a given increment of heat in inverse proportion to the specific heats, thus, $\frac{dv}{v} = \frac{dP\,kv}{K\,kp}$. Suppose a quantity of gas at volume V, and pressure P, to be expanding freely behind a piston, then if the change of volume $Kp\,\frac{dv}{v}$, combined with the change of pressure $Kv\,\frac{dp}{p}$, produces a change of temperature $d\,t$, that is, the sum of the changes produces a change $d\,t$ or conversely;

$$\text{then as } Kp\,\frac{dv}{v} + Kv\,\frac{dP}{P} = O \text{ (a minimum)}$$

$$\therefore Kp\,\frac{dv}{v} = Kv\,\frac{pP}{P}$$

$$\text{from which } dP = \frac{Kp}{Kp}\,P\,\frac{dv}{v}.$$

Without here introducing the mathematical proof of those relations, it may be useful merely to notice the results, for they are equally applicable in the general form to any gaseous body, viz.,

$$\frac{T^1}{T} = \left(\frac{V}{V^1}\right)^{\gamma-1} = \left(\frac{P^1}{P}\right)^{\frac{\gamma-1}{\gamma}} = \frac{P^1\,V^1}{PV}.$$

Where T is the absolute temperature of any gas, i. e., the sensible temperature added to a constant 461° F. or 273° C., at a certain pressure P and volume V, while T_1 is the absolute temperature at any other pressure P_1 and volume V_1. The Greek letter γ (gamma) when used in this connection is understood to mean the relation $\frac{Kp}{Kv}$, and it is this value which is the main factor in the mathematical solution of the adiabatic curve.

Instead, therefore, of the constant number we obtain by simply multiplying the pressure and volume together ($P\,V$) we have as a constant the value $P\,V^{\gamma}$ where γ is the power to which V must be raised. Authorities have given us the values of γ—for dry saturated steam $\frac{17}{16}$, superheated or gaseous steam 1.3, and wet ordinary steam $\frac{10}{9}$; but even these values are empirical and the accuracy of any one of them mainly depends upon its selection. Let us take the case of ordinary or wet steam, as it is called, and see how the constant $P\,V^{\gamma}$ or $P\,V^{\frac{10}{9}}$ may be applied to the construction of an expansion curve. In the case we have already considered, $P = 100$ and $V = 4$, $\therefore P\,V^{\frac{10}{9}} = 100 \times 4^{\frac{10}{9}}$. To raise 4 to the $\frac{10}{9}$ power we may make use of a table of logarithms, thus: $\log 4 = .60206 \times \frac{10}{9} = .66895 = \log 4.666$, $\therefore P\,V^{\frac{10}{9}} = 100 \times 4.666 = 466.6$. We have supposed that steam is carried $\frac{4}{10}$ of the stroke, and to find the pressures corresponding to volumes 5, 6, 7, 8, 9, and 10, we may place it in this form—

$V = 5$. $5^{\frac{10}{9}} = log\ 5 \times \frac{10}{9} = .699$
$\times \frac{10}{9} = .776 = log\ of\ 5.98$ $\Big\}$ $\therefore P_5 = \frac{466.6}{5.98} = 78.04\,lb.$

$V = 6$. $6^{\frac{10}{9}} = log\ 6 \times \frac{10}{9} = .7782$
$\times \frac{10}{9} = .8647 = log\ of\ 7.233$ $\Big\}$ $\therefore P_6 = \frac{466.6}{7.323} = 63.7$ "

$V = 7$. $7^{\frac{10}{9}} = log\ 7 \times \frac{10}{9} = .8451$
$\times \frac{10}{9} = .939 = log\ of\ 8.69$ $\Big\}$ $\therefore P_7 = \frac{466.6}{8.69} = 53.7$ "

$V = 8$. $8^{\frac{10}{9}} = log\ 8 \times \frac{10}{9} = .9031$
$\times \frac{10}{9} = .10034 = log\ of\ 10.08$ $\Big\}$ $\therefore P_8 = \frac{466.6}{10.08} = 4.63$ "

$V = 9$. $9^{\frac{10}{9}} = log\ 9 \times \frac{10}{9} = .9542$
$\times \frac{10}{9} = 1.06 = log\ of\ 11.48$ $\Big\}$ $\therefore P_9 = \frac{466.6}{11.48} = 40.7$ "

$V = 10$. $10^{\frac{10}{9}} = log\ 10 \times \frac{10}{9} = 1.000$
$\times \frac{10}{9} = 1.111 = log\ of\ 12.91$ $\Big\}$ $\therefore P_{10} = \frac{466.6}{12.91} = 36.1$ "

Those pressures as before are marked off to scale and the curve drawn through the points. Those are strictly mathematical solutions of the expansion curve, and the operations, though somewhat tedious, are absolutely necessary to an intelligent conception of the principles on which the graphic or geometrical solutions depend. To construct a hyperbolic or simple $P\,V$ curve by the latter method, let the actual indicator diagram Fig. 8 be taken to illustrate the method employed. This is taken from one end of a high-pressure engine. $A\,B$ is the perfect vacuum line drawn to scale 14.7 lb. below the atmospheric line $C\,D$. $A\,E$ represents the clearance in proportion to the volume of the cylinder $E\,B$. If a diagonal be drawn from A at an angle of 45°, or one-half the right angle $H\,A\,B$, then this will be the axis of every hyperbola having its origin at A, that is to say, corresponding portions of the curve on either side of it are exactly alike. Take any point F, preferably just before exhaust opens, and

from F drop a perpendicular to the base $A\ B$ cutting in G. Divide $A\ G$ into any number of divisions (not necessarily equal) and erect perpendiculars through those points from the base $A\ B$. From A cut off $A\ J$ equal to $F\ G$ and draw $J\ I$ at right angles to the base $A\ B$. From J cut off $J\ I$ equal to $A\ G$. Then the point I will be another point in the hyperbolic curve, because pressure and volume being interchangeable quantities, the volume $A\ J \times$ the pressure $J\ I$ is made equal to the volume $A\ G \times$ the pressure $F\ G$. Draw H_{10} equal and parallel to the base line $A\ G$, then join A_2, A_3,

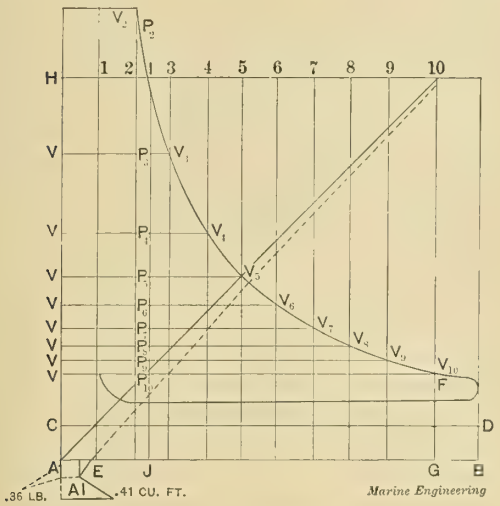


FIG. 8

A_4, A_5, A_6, A_7, A_8, A_9, and A_{10}, and where those lines cut the perpendicular $J\ I$ in P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, and P_{10}, those points will represent the pressures corresponding to their respective volumes VV_2, VV_3, VV_4, VV_5, VV_6, VV_7, VV_8, VV_9, VV_{10}. A curve drawn through the points V_2, V_3, etc., is an hyperbolic or isothermal curve, and is said to be the curve of ideal expansion. There is another curve by which the real expansion curve of an indicator diagram is often compared, viz., the saturation curve. Acording to Rankine, this may be worked out on the same lines as the example we have just considered, but that instead of a constant $V\ P\ \frac{10}{9}$ constant we are given $V\ P\ \frac{17}{16}$. As already observed, it is very desirable that we should be able to construct such a curve by the graphic method. It has been proposed by Fairbain and Tate as a substitute for Rankine's formula for the curve of saturated steam to employ the same method as is employed in the geometrical delineation of the hyperbolic curve, but that instead of making the origin of the axis as at A in Fig. 8, it is merely shifted by adding .36 lb. to the pressure, i. e., below the perfect vacuum line, and subtracting from the volume in cubic feet .41 cu. ft. In the diagram shown, Fig. 8, $A\ G$ is supposed to represent the volume in cubic feet of 1 lb. weight of steam at a pressure corresponding to $G\ F$. If the pressure $G\ F$ be 40 lb. absolute per square inch, then $A\ G$ will represent a volume of about 10.3 cu. ft., which is the space occupied by 1 lb. weight of steam at this pressure. With the point thus found we may proceed as before. The curve thus drawn approaches very nearly to Rankine's formula for saturated steam, $P\ V^{\frac{17}{16}}$. The difference between this and the adiabatic curve is that in the latter a certain amount of water is present due to the performance of work, while in case of a saturation curve the steam is supposed to be free from water by the transmission of heat from a steam jacket or other source. But of all the theoretical curves that may be drawn, the hyperbola is the most important. It fulfils the law in the broadest sense, and is a standard by which all others may be compared.

It may be conceded that the application of the indicator in calculating the effective stresses on the transmitting parts of a reciprocating engine does not strictly come within the scope of this essay, but it may be well to point out the modifications which the diagram must undergo in order to present a true picture of the effects of converting the reciprocating motion of the piston to the rotational movement of the shaft when conveyed through the combination of piston and connecting rods and a crank. The indicator diagram is primarily a true measure of work as applied to the piston, and only the ultimate effects are necessary factors in such a calculation. It is immaterial, as far as the mere work is concerned or the behavior of the steam, whether the velocity of the piston be uniform throughout the stroke, whether the motion be uniformly accelerated or variably accelerated, the ultimate effect is in moving the piston a certain distance against a certain resistance. The absolute pressure or motive force varies at every point of the stroke after steam is cut off, and the total resistance (neglecting friction) is the sum of the absolute back pressure or resisting force added to the resistance of the crank pin through the center line of the conecting rod. The resistance due to back pressure is fairly uniform ouring the greater part of the stroke, but varies toward that extremity which includes the compressive curve, while the resistance of the crank pin to tangential motion varies with every angle which the conecting rod makes with the crank arm. In order to compare the force at work it will be necessary to present the laws upon which their magnitudes depend, and to state as clearly as possible the exact definition of the terms employed. All forces are comparative in their effects, and the laws regulating the motion of a falling body, under the attraction of the earth or under the influence of gravity, are taken to be true as regards the motion of a body under the influence of any other force. Velocity—is the speed of a body measured in relation to the distance it would fall in a unit of time if the force under which it has acquired that velocity ceased to act, and under the action of a uniform force it varies as the time and the acceleration. Acceleration—is the rate of change of velocity in a unit of time and varies directly as the force under which it is generated. Space—is the distance in units of length, in which a body acting under the influence of a uniform force acquires a certain velocity and varies as the acceleration and the square of the time. The laws relating to motion under the simple attractive force of the earth may be thus symbolically stated when the body starts from rest, if $v =$ terminal velocity, $t =$ units of time, $s =$ space passed over, and $g =$ acceleration due to gravity $=$ a force of 32 units. Then $v = gt$, $s = 1\text{-}2\ gt^2$ and $v^2 = 2gs$.

If, then, we suppose the crank pin to revolve with a uniform speed, that is, if it describes equal arcs of a circle in equal intervals of time, the distances that the piston moves from either extremity of its stroke will depend on the versed sines of the angles which the crank arm makes with the center line of the engine, and that which the connecting-rod makes with the same line of centers. In Fig. 9, let *D B a* be the crank circle, and *A B* any position of the crank. From *B*, with a distance equal to the length of the connecting-rod, cut the center line in *C*, and from *C* with the same radius describe the arc *B G*. From *B*, draw *B F* perpendicular to the center line and cutting it in *F*. It will thus be seen that the distance *D G* is equal to *E C*, that is, the distance which the piston has moved from the dead point *E*. But *D F* is the versed sine of the angle *D A B*, and *F G* is the versed sine of the angle *B C G*, therefore the total distance *D G* or *E C* is the sum of those versed sines in the first quadrant of a revolution and their difference in the second, measuring from the opposite extremity D_1. Now, in order to convert an ordinary indicator diagram from a measure of work to a diagram of pressures on the crank pin, not only the distance traveled by the piston from rest is necessary, but also the relative velocities or accelerations occurring at each interval of the stroke. The mean velocity of the piston may be represented by the distance it has traveled in any interval of time, but with a uniform rotation of the crank the angular motion is more convenient and is the equivalent of time.

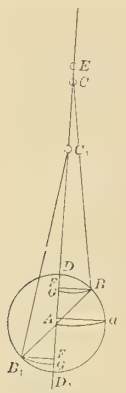


FIG. 9.

The spring cruise of the North Atlantic squadron was begun February 16, when the flagship New York, Rear-Admiral Sampson, and the battleship Indiana left the anchorage at Tompkinsville, S. I., for Bermuda. From there they will proceed to Havana, where several other vessels will join the squadron, and then to Cienfuegos, where they will arrive about March 5. Afterward the vessels will visit Guantanamo, and then this itinerary will be followed: Kingston, March 19 to 23; San Juan, Porto Rico, March 26 to 29; Martinique, March 31 to April 3; Barbados, April 4 to 7; Trinidad, April 8 to 13; La Guayra, April 15 to 18; Cartagena, April 21 to 24; and New York, May 3. The squadron will cover about 7,000 miles during the cruise.

Sinking of S.S. Germanic in Hudson River.

A peculiar accident happened to the White Star liner Germanic while alongside her pier in the North river, New York. She arrived from Liverpool after a stormy passage on Saturday, February 11, and the work of getting out her cargo was proceeded with rapidly, as she was billed to sail on her return voyage on the following Wednesday at noon. She was moored alongside the pier, which was on her port side, at a sufficient distance to permit the coal barges to come to the port as well as the starboard side. On Monday night, while the coal barges were alongside and the work of filling the bunkers was going on, and while the stevedores were at work in the hold, the vessel suddenly listed to starboard. An effort was made to right her by trimming, and then, according to present reports, she righted and immediately careened to port, toward the pier, with the result that her coaling ports on that side were submerged and she filled rapidly. As the water is shallow she soon reached bottom and began to settle in the mud. Wreckers were shortly put to work to pump out the vessel, and divers made repeated and unsuccessful efforts to close the ports. The views here published were taken the next day, but subsequently the vessel settled deeper, and in less than a week her hull was submerged at high tide as far forward as the forecastle.

Until an investigation is made it will not be possible to determine the exact cause of the mishap, which was apparently due to negligence. A lack of care in trimming the vessel in port was, probably, the chief cause, though contributory causes are said to have been the great masses of ice on the upper works and spars and the pressure of a strong wind blowing abeam.

The sailing of the vessel has, of course, been indefinitely postponed, and the mails which she was to have carried out were forwarded to Boston to go East on the Dominion liner Canada. It is probable that thousands of dollars' worth of interior furnishings and finishings, and stores, have beeen rendered worthless by the flooding.

Other than a slight collision in the Mersey a few years ago this is, we believe, the first serious mishap that has befallen this vessel. She is one of the very oldest first-class liners in service to-day. With the Brittanic, her sister ship, she shares the reputation of being one of the most successful liners ever built. She is one of the original vessels of the White Star fleet, and was built in 1874 by Harland & Wolff at Belfast. Her dimensions are: Length, L. W. L., 455 ft.; beam, 45.2 ft.; and depth, from main deck, 33.7 ft. Her gross tonnage is 5,066 tons. She is an iron, single-screw vessel with four masts, and is fitted with eight bulkheads. She was originally fitted with compound engines and boilers carrying 75 lb. pressure. In 1895 new machinery was fitted at the builders' yard, including triple-expansion engines and Scotch boilers. At that time she had made nearly 300 round trips across the Atlantic, and had steamed about 1,700,000 miles and carried in all about 260,000 passengers.

Such mishaps, though rare, are not unknown. The most notable, perhaps, was that which occurred to the

STERN VIEW OF S.S. GERMANIC AFTER SHE HAD TOUCHED BOTTOM.

S.S. Austral, of the Orient line, in the freight and passenger trade between English and Australian ports. When coaling in Sydney harbor, several years ago, she suddenly turned turtle and sank.

BOW VIEW OF S.S. GERMANIC ALONGSIDE HER PIER IN NORTH RIVER, N. Y.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—II.

BY C. H. PEABODY, B. Sc.

If the engine is placed aft in the run of the ship, as is customary on some lake steamers and some tank steamers, then the cylinders should be arranged in the reverse of the usual order—that is, the low pressure cylinder should be forward, as shown by Fig. 5. If the reciprocating parts have the proportions given by Schlick, then the low pressure cylinder should be aft of the node at a distance equal to five times the common interval between the cylinders.

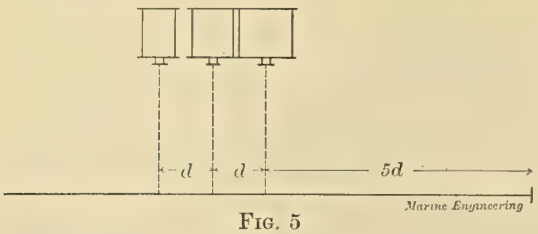


FIG. 5

A common practice on the Great Lakes is to put the high-pressure cylinder between the intermediate and the low pressure cylinders to save room, the low pressure cylinder being aft. If the low pressure cylinder should be placed forward, then, by an investigation similar to that given in the preceding note,* the location for the engine can be sought that will give least trouble from shaking.

Some triple-expansion engines have been built with two low-pressure cylinders, making four in all, arranged as shown by Fig. 6. The cranks for the high-pressure and the intermediate cylinders are opposite,

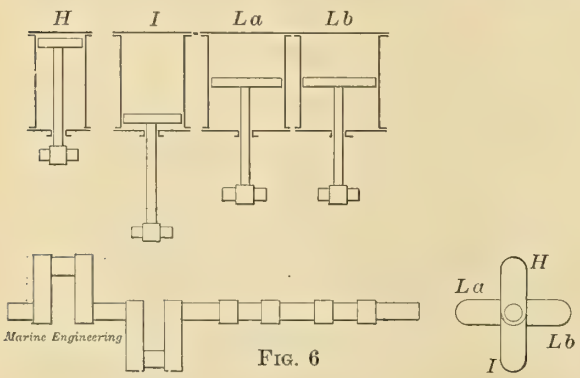


FIG. 6

as are also the cranks for the two low-pressure cylinders, but the two pairs of cranks are at 90 deg. The result is that the engine is very nearly in standing balance, and if deemed important that balance can readily be made complete by loading the high-pressure piston. The engine has, however, very considerable rocking couples at high speed, and consequently some engines which have been arranged in this way at the expense of considerable inconvenience in the design of the ship have proved disappointing, which is not surprising, since engines are more often near a node than a loop. If this arrangement of cylinders is chosen then the valve chests of the high-pressure cylinder should be in front and the valve chest for the intermediate cylinder should be turned aft so that these cylinders may be placed near together and so shorten the distance between their crank-pins and diminish the rocking couple that they will set up. In like manner the low-pressure cylinders should be placed back to back. The writer has seen this arrangement of valve chests just reversed, so that the two low-pressure cylinders had their valve chests between them, and consequently their cranks were widely separated, and being opposite, could set up a very considerable rocking couple. The high and intermediate cylinders were separated in a like manner though not to so wide a distance.

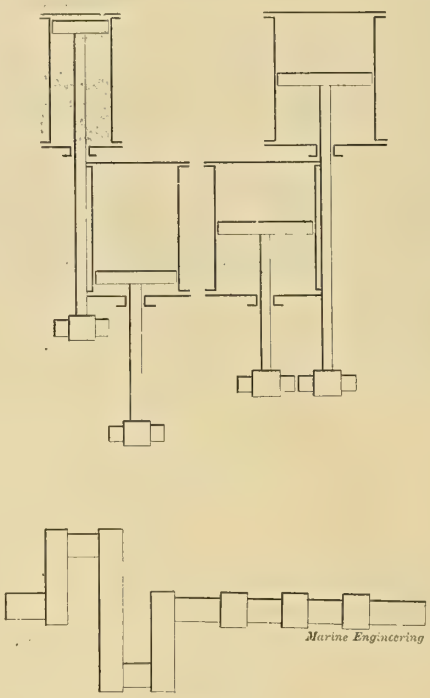


FIG. 7

Any four-cylinder engine, such as a quadruple-expansion engine, can be arranged in pairs and will then be nearly in standing balance and can readily have the balance made perfect if desired. It will of course have rocking couples, as has been pointed out.

In order to reduce the rocking couples to a very small amount Mr. Herreshoff has used the arrangement shown by Fig. 7 for a four-cylinder triple-expansion engine. The two low-pressure pistons are in exact standing balance and the high-pressure and intermediate pistons are very nearly in standing balance. The engine also has the distinct advantage that the thrust of the descending piston and the pull of the ascending piston of a pair are very nearly equal; there is therefore but a small amount of pressure on the main bearings, which therefore are little likely to give trouble from heating. Of course the arrangement shown by Fig. 6 has somewhat of the same effect, though less perfectly, as there is an intermediate bearing, which is required on account of the spring

* See note on p. 7 of February, 1898, issue of Marine Engineering.

of the intermediate crank shaft and the two intermediate crank cheeks. The chief objection to this claim is the difficulty of opening the two inside cylinders; for the engine represented by Fig. 7 there was a carefully worked out arrangement for taking down the lower cylinder head, which of course required the removal of the guides and the disengagement of the connecting-rod.

For some earlier engines of small size Mr. Herreshoff obtained the same result, that is, the removal of the intermediate bearing for a pair of opposite cranks, by shifting one of the two cylinders over to the port and the other to the starboard. When the cylinders do not have too large diameters in comparison with the stroke a shifting of their axes, or lines of dead points, about 15 deg. from the vertical will allow us to place them at the same height and still have them act on a pair of opposite cranks with only a continuous crank web between the crank-pins, as shown by Fig. 7. The cylinders will then appear as shown by Fig. 8. This arrangement of cylinders has beeen used on a large

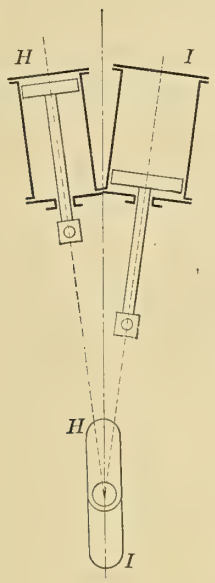


Fig. 8.

scale by Mr. Thornycroft for torpedo boats and torpedo-boat destroyers, and with very good results. The engines are indeed neither in standing nor in running balance, but the lack of balance, either standing or running, is not important for such engines and they do not produce excessive shaking. But when the diameter of the cylinder becomes greater than the stroke such an arrangement of the cylinders is likely to throw their axes 30 deg. out of the perpendicular and to lead to very undesirable proportions and arrangements of details, to say nothing of the fact that they will be far from balanced either when standing or when running.

Having considered the cause of vibrations of a steamship, and the effects that various arrangements of engine cylinders and cranks may have to aggravate or ameliorate the evil, let us investigate the methods that have been proposed for balancing engines and thus avoiding vibrations. The ill effects of the accelerating forces acting on the pistons of an engine were earliest felt on locomotives with outside cylinders as commonly arranged in America. The cranks are of course set at 90 deg., to insure certainty of control in starting and stopping, and consequently the piston on the right-hand side is at the middle of its stroke when the left-hand piston is starting at the beginning of its stroke. The right-hand piston is at its highest speed and there is no accelerating or retarding force acting on it, but there is a large accelerating force required to start the left-hand piston, which tends to slew the locomotive sideways on the track. Four times in each revolution such a slewing of the locomotive occurs, first one way and then the other, which tends to throw the locomotive off the track. To overcome this difficulty balance weights are cast between the spokes of the driver wheels, which are intended to counterbalance the accelerating forces acting on the reciprocating parts, i. e., the piston, piston-rod, crosshead, connecting-rod and side-bar. It is not necessary to go into the details of this method of balancing nor to point out its defects further than to call attention to the fact that the counterweights are always affected by a constant centrifugal force when the engine is running at a constant speed. This centrifugal force can be made to give a very good balance of the reciprocating parts when they are at the end of the stroke, but when those parts are at the middle of their stroke then the centrifugal force acting on the counterweight is entirely unbalanced. When the counterweight is down, between the driver axle and the track, the centrifugal force produces an added pressure of the driver wheel on the track in excess of the weight carried by that wheel when the locomotive is at rest. When the counterweight is up it tends to lift the wheel off the track. Consequently the counterweights produce a rocking of the locomotive from side to side, which however is less dangerous than the slewing of an engine without counterweights.

Marine engine builders often attempt to counterweight their engines in a similar way, but the transverse throw of the counterweight when the piston is at the middle of the stroke is likely to be quite as bad as the vertical accelerating force of the piston, when the engine is unbalanced, that is, if the engine is heavily counterweighted. Consequently marine engine designers are usually content to balance the crank shaft itself, or, at most, to counterweight for a part of the connecting-rod. To balance the crank shaft it is customary to extend the crank check or slab beyond the shaft and bolt on a cast-iron counterweight. The moment of the extension of the slab and the counterweight must be equal to the moment of the crank cheek and half the crank pin. Some engineers add the moment of one-third the weight of the connecting-rod; if more than one-third is provided for the transverse throw is liable to be unpleasant. There is an objection to counterweight on the part of the engine attendants, as it much enhances the danger of caring for the main bearings when the engine is running, especially to a man who has been accustomed to an unbalanced engine.

(To be continued.)

New York Fireboats in Action.

A serious fire in the down town district in New York on Thursday, February 9, called into use the powerful fireboats Robert A. Van Wyck and The New Yorker, in addition to twenty-five land engines and a water tower, besides a variety of other fire apparatus. It broke out early in the day in a block of buildings in the shipping district, close to South Ferry; the block being bounded by Front, Moore, South and Whitehall streets. Many of the buildings in the block were built of wood, very old and dried out, so that the fire burned with unusual fierceness. As the fire was too far distant from the water's edge to use the fixed nozzles on the fireboats the deck couplings were connected with hose to the water tower, which sent a regular cataract of water over the burning buildings, and also to the hand nozzles on shore. The weather was intensely cold, about zero, and the firemen suffered severely. As the water poured out of the windows and doors it froze, decorating the buildings picturesquely, as shown in our photograph. Notwithstanding the tremendous quantity of water used the fire was not put out until about $750,000 worth of property had been destroyed. In the photograph the two fireboats are shown with their noses against the bulkhead at the shore line. During the progress of the fire the tide fell and both vessels were aground. The suction openings, being so near the bottom, let into the pumps a good deal of dirt in suspension in the water, but this mixture was apparently as effective in smothering the flames as the unadulterated water of the East river. The reproductions of the photographs taken during the progress of the fire will be found on the opposite page.

According to report, work on the new yacht for Anthony J. Drexel, of Philadelphia, will be begun at once in the Scott yard at Greenock, on the Clyde. Designs have been prepared by G. L. Watson, and the yacht will be a large sea-going vessel of the Mayflower type. Her dimensions will be: Length, 268 ft.; beam, 36 ft.; depth, 20 ft., and net tonnage about 1,800 tons. She is to be fitted with twin-screw triple-expansion engines capable of developing about 4,700 I. H. P. and of drivng the boat at the rate of 17 knots.

The U. S. S. Buffalo arrived out at Manila February 3 with a cargo of supplies and 700 sailors as relief crews for Admiral Dewey's fleet. The voyage from New York occupied fifty-four days. This vessel, it will be remembered, was originally the Morgan liner El Cid, and later was purchased and fitted up as a dynamite cruiser by the Brazilian Government. Shortly before the Spanish war she was purchased by our Navy, and will now be used as a transport on the Pacific ocean.

A course in marine engineering has been established at Columbia University, New York, and the chair will be occupied by William Ledyard Cathcart, who has been acting in the same capacity at Webb's Academy.

CONSIDERATION OF THE VOLTAGE USED IN ELECTRIC SHIP LIGHTING.

BY ALTON D. ADAMS.

The voltage or electric pressure to employ is one of the first and most important points for decision in the design of an electric plant for ship lighting.

In the United States Navy the standard is 80 volts; isolated plants on land usually employ 110 volts, but in some more recent work a 220-volt pressure has been selected. Just why the 80-volt pressure has been so much used on ships seems uncertain, but a desire to keep near the pressure required for searchlights is sometimes given as the reason.

Search lamps require about 45 to 50 volts at the arc and a drop of 15 to 20 volts, through resistance in series with the lamp, to insure steady burning, so that about 65 volts is all that is necessary for these lamps.

For isolated land plants the pressure of 110 volts was selected at a time when satisfactory incandescent lamps could not be had for much higher pressure, and the advantages of uniformity have operated against moderate changes in lamp voltage.

Within the last few years improvements have made it practical to produce the 220-volt lamp, and it is being slowly introduced on new work. In the future an increasing number of new plants, having lamps at some hundreds and thousands of feet from the dynamo, will beyond doubt use the 220-volt lamp; but for the present a 110-volt lamp must be regarded as standard for most isolated plants.

Questions of insulation and fire risk mainly tend to retard change to the 220-volt system, because during its years of use there have been perfected for the 110-volt system a line of fixtures and fittings known to be safe and reliable to a high degree. It is also known that many of the 110-volt fittings will not stand the strain of 220 volts with safety, and time and experience will be required to perfect fittings for the higher pressure. A parallel can be drawn with steam, for it is well known that steam pipes and fittings which are quite satisfactory at 110 lb. pressure would not be safe at 250 lb.

The advantage obtained by increased voltage of incandescent lamps is due to the law that for any given distance the weight of copper required to supply any number of lamps varies inversely as the square of the voltage. For example, the relative weights of copper wire to feed a certain number of incandescent lamps at any distance from the dynamo on the 80, 110 and 220 volt pressure will be as $(80)^2 = 6{,}400$, $(110)^2 = 12{,}100$ and $(220)^2 = 48{,}400$. This shows that wiring at 80 volts requires about twice the copper necessary for 110 volts, and wiring at 110 volts about four times the copper for 220 volts.

Another fundamental law of electric circuits is that the weight of copper wire to feed any number of lamps of given voltage varies directly as the square of the distance between the dynamo and lamps. Thus 100 lamps 75 ft. from the dynamo require but one-quarter the copper necessary if they are 150 ft. from the dynamo.

The full theoretical advantage due to increased volt-

age cannot be obtained in the small branch wires of a system, as these wires must not be reduced below a certain size for reasons of mechanical strength. This consideration, however, effects the saving possible with increased voltage but little, as most of the weight is in the large feed wires and mains.

From the two fundamental laws already stated it is evident that the greater the distances between dynamo and lamps the more saving is to be effected by the use of high voltage.

Coming now to the practical question of what voltage to employ for the average ship plant, the 110-volt pressure offers a saving of nearly one-half the copper required by the 80-volt wiring, while the same class of fixtures and fittings are used for either pressure. The 220-volt wiring requires only one-fourth the copper of the 110-volt; but a more expensive and to some extent untried class of fittings must be used and greater care taken to insure insulation throughout.

As most ship plants do not operate lamps more than two or three hundred feet from the dynamo, so that total cost of wire is but a moderate part of that for the entire plant, as risk from fires due to poor insulation are especially dangerous at sea, and as repairs to fittings may be especially inconvenient during a voyage, the pressure of 110 volts seems best suited for ship plants at the present time. The fact that search lamps require, with the resistances necessary for steady operation, only about 65 volts seems the only valid objection to the 110-volt pressure, and this in a plant of medium or large capacity is of small moment. Moreover, the 80-volt pressure is open to the objection of waste, though not in the same degree.

Consider the case of a nominal 4,000-candle-power searchlight requiring 20 amperes at about 50 volts. To reduce a pressure of 80 volts on mains to 50 volts at the lamp a resistance coil must be connected in series with the lamp to have in it a drop of 30 volts with 20 amperes flowing. This resistance, therefore, consumes power at the rate of $20 \times 30 = 600$ watts, or $600 \div 746 = .8$ horse power. With a 110-volt pressure on the line the resistance with lamp must cause a drop of $110 - 50 = 60$ volts, and the power consumed with 20 amperes is $60 \times 20 = 1{,}200$ watts, or $1{,}200 \div 746 = 1.6$ H. P. The difference in regulating resistance loss between the 80 and 110 volt system is therefore $1{,}200 - 600 = 600$ watts or .8 horse power, which in case of a 50-horse-power plant would be less than 2 per cent. The fact that a searchlight is usually in operation a small part of each day makes the relative loss still smaller on the average. On the other hand the amount of copper required for a given per

SCENES AT THE WATER-FRONT FIRE NEAR SOUTH FERRY IN NEW YORK CITY.

cent of loss in the 80-volt wiring will often lead to a larger per cent of loss than would be employed with 110 volts, so as to more than offset any saving in searchlight resistance.

The enclosed arc, which has about the carbon points a small glass or porcelain cylinder, nearly air tight, requires about 80 volts at the lamp and would thus save one-half the resistance-coil loss of a lamp on the 110-volt circuit. This 80-volt arc lamp could not be used on the 80-volt circuit, as arc lamps operated from constant pressure mains require the line pressure to be reduced at least 25 per cent to insure steady working of the lamps. Not only does the 80-volt system require twice the weight of copper wire, but the capacity of main switches, number of brushes at commutator and the size of contact surface on commutator must be about one-half greater than that for the 110-volt plant.

The commutator requirements just named add something to the length and weight of dynamo and to the attention necessary at brushes. Having so little against it and so many points of advantage the pressure of 110 volts may reasonably be expected to grow in favor for ship-lighting plants.

Lord Charles Beresford, the dashing Britsh naval officer, is now in this country on his way home from an official visit to China in the interest of the British Associated Chambers of Commerce. He is one of the strongest advocates of the "open-door" policy in the Far East, and while here he is endeavoring to obtain the views of American Chambers of Commerce with regard to the future development of trade and commerce with the Chinese Empire. In the course of an interview which he gave to a representative of the press he said:

"The very astounding performance of the battleship Oregon in her long run from San Francisco to the scene of hostilities in the Atlantic challenged the admiration of naval men throughout the world. While this is a remarkable tribute to the genius of the builders and those who equipped her, it could not have been accomplished without the most devoted attention to details on the part of the captain, officers and ship's company, particularly the chief engineer, engineers and firemen, who stood the long strain so manfully."

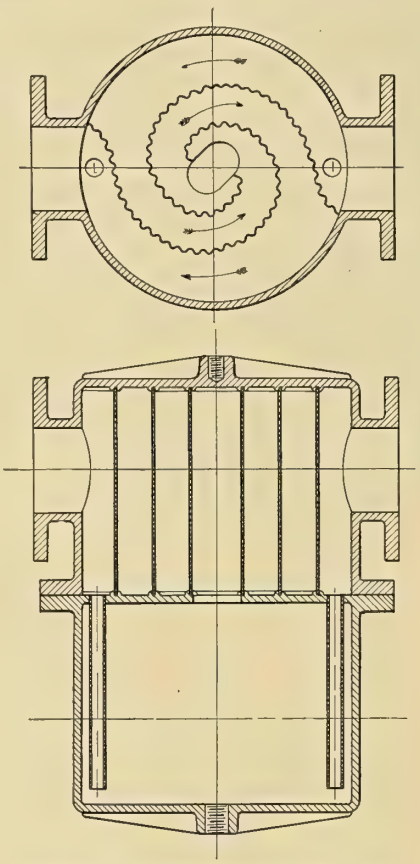
Lord Beresford is a high authority in naval matters, not only theoretical, but practical. He took part in the bombardment of Alexandria in command of H. M. S. Condor, and for special bravery in placing his vessel close in he was rewarded by the famous signal made by the British Admiral, "Well done, Condor."

The new steel yacht Willada, for Colonel William Hester, of Brooklyn, now under construction at Wilmington, Del., will measure: Length, 102 ft.; beam, 16 ft. 6 in.; depth, 9 ft. 3 in. She will be fitted with a triple-expansion engine, 9 in., 14 1-4 in. and 23 1-2 in. by 14 in., built by the Fore River Engine Co., of Weymouth, Mass., and will have an Almy water-tube boiler. Colonel Hester is well known in yachting circles as owner of the sloop Wizard.

IMPROVED APPARATUS.

Hutchison Separator.

The accompanying figure shows a new steam and oil separator, designed by Richard Hutchison, Tremont Building, Boston. The body is cylindrical and divided into upper and lower compartments by a horizontal partition. In the upper compartment a corrugated copper diaphragm is arranged so that any vaporous current passing through this chamber is made to travel by an inverging and outverging spiral path always in the same horizontal plane. The steam or vapor is not only brought in contact with a large amount of impact surface, but foreign matter, being heavier than the current, is thrown by centrifugal action against the diaphragm as well, from whence it runs down the corrugations, without again crossing



SECTIONS OF HUTCHISON SEPARATOR.

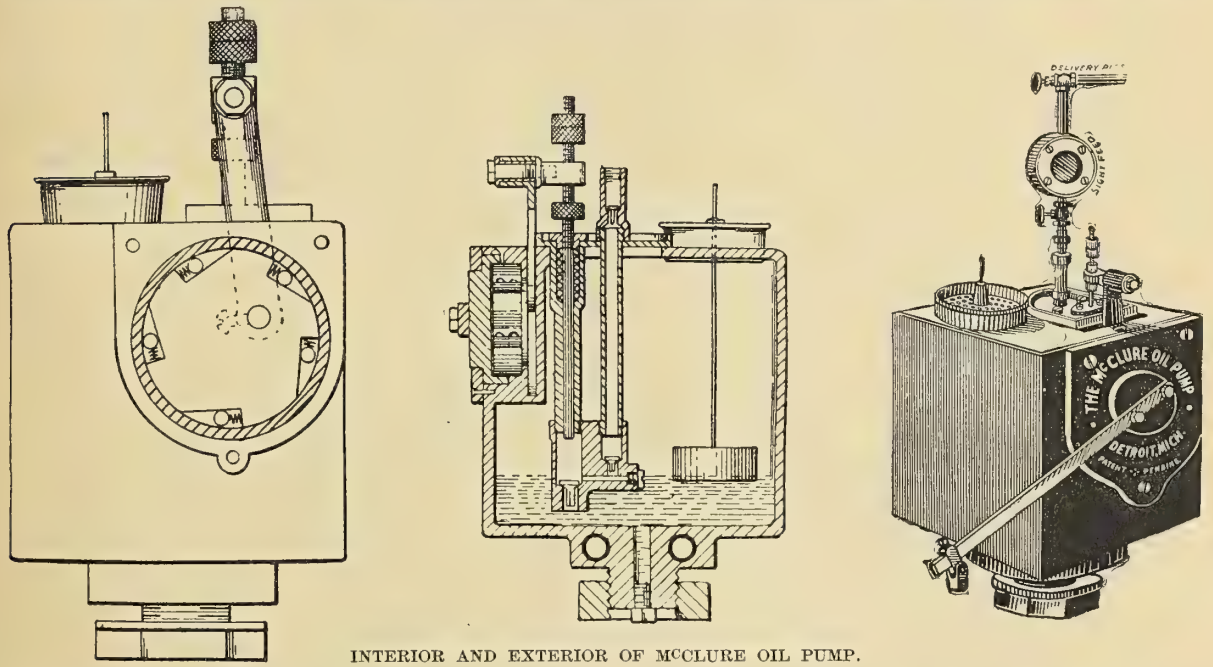
the current of vapor, into the reservoir below. This reservoir can be drained automatically by a trap. The copper diaphragms in the cut shown here are held in place by their serrated edges being forced into taper spiral grooves, when the upper and lower parts of the separator are bolted together. The elliptical opening through the centre of the horizontal partition will usually be of ample capacity, but small drips are provided as well in the event of an unusual influx of water, when some might be carried past the central opening. Either nozzle may be used as the inlet, so that as regards the water glass rights and lefts are not necessary.

These drips are carried down so that the water in

the lower chamber will form a seal and prevent steam short-cutting down one and up the other. The lower chamber is designed unusually large, with a view to having it act as a receiver for the engine containing steam supply ample to satisfy an unexpected demand, thereby preventing pulsations and combining the consequent advantages. These separators below, 4 in. in size, are cast complete in two pieces and bolted together by a vertical body flange; from 4 in. to 8 in. they are made as shown in the cut, and above 8 in. the shell is steel plate, with cast steel nozzles riveted on.

Lubricating Oil Pump.

The illustrations show an improved form of forced feed, known as the McClure lubricating oil pump. It is intended for cylinder lubrication either with the main engines, or dynamo, fan or steering engines, and can also be used for lubricating working parts, such as the crossheads and guides. The pump is attached to the frame of the engine and is connected with some moving part, so that the speed of the pump will vary with the speed of the engine. The pump body is made of cast iron, with a capacity of one quart or half a gallon, according to size. This contains the pump mechanism, as shown in the sectional view. The pump plunger is fitted with adjustable nuts, so that the quantity of oil delivered at each stroke can be regulated very exactly. The plunger is driven by a link attached at its lower extremity to a ratchet plate, which is rotated by contact with a ring or cap and arrangement of rollers, this ring being connected outside with a reciprocating portion of the machine to be lubricated. The valves are inserted from the top of the lubricator, so that they can be withdrawn readily for examination. A cork float with indicator-rod is used to show the oil level in the receiver. When used for cylinder lubrication an independent sight feed attachment is supplied. The makers state that this lubricator has been used with excellent results. The address is the McClure Oil Pump Co., Detroit, Mich.



INTERIOR AND EXTERIOR OF MCCLURE OIL PUMP.

Generating Set for Shipboard.

A compact generating set for ship lighting is shown in the accompanying engravings of a B. F. Sturtevant installation on the steamship Berlin, of the American Line. The engine is of the twin-cylinder, high-pressure, fly-wheel-governed type, with cylinders 9 in. dia. and 5 1-2 in. stroke, direct connected to a continuous-current generator, having a capacity of 40 K. W. Both engine and generator are mounted on one base, and the weight, set up ready for use, is 10,000 lb. The engine is designed with a view to the specially trying conditions of shipboard work, having all parts made with good proportions of the highest class materials, and with large wearing surfaces. The two cylinders and valve chests are in one casting, carried on stout columns, square at the back and turned in front. Each cylinder has a separate piston valve, and both are worked from the same crosshead, which receives its motion from a rocker arm fulcrumed between two of the supporting columns and operated by the eccentric rod, connection with the rod being made by a ball and socket joint. The position of the eccentric is controlled by the fly-wheel governor, which is of the Rites type. The engine cranks are set opposite, that is, at 180 deg., so that as one piston goes up the other goes down. Both valves, however, travel in the same direction at the same time. In order that, notwithstanding this, steam may be admitted to the top of one cylinder at the same time that it is admitted to the bottom of the other, the inside of one valve is used for steam and the outside for exhaust, while in the other valve the steam is on the outside and the exhaust on the inside. Live steam entering, as shown in Fig. 1, passes to the ends of valve 1, as shown in the section through *A B*, Fig. 2, and to the middle of valve 2, as shown in the section

through *C D*, Fig. 3. When the valves are in the positions shown, cylinder 1 will be taking steam on top and cylinder 2 on the bottom. The valves are fitted with snap rings and travel in removable bushings. The crossheads are of the slipper type, with projecting crosshead pins, the rod ends being yoked, thus furnishing ample pin surface. The crank pins are 4 1-2 in. long and 4 in. dia. The crank shaft is

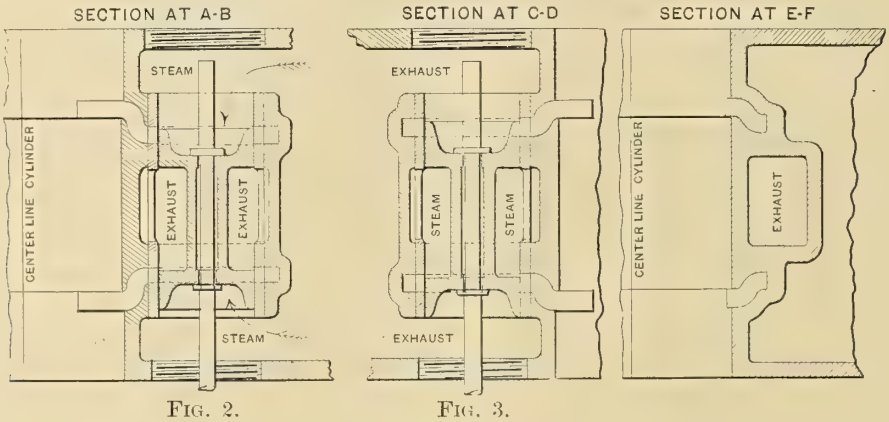


Fig. 2. Fig. 3.

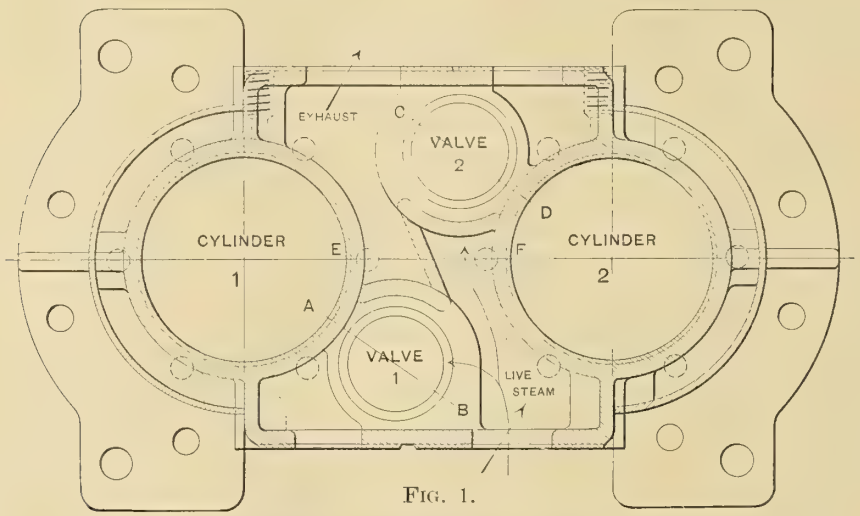


Fig. 1.

SECTIONS THROUGH CYLINDERS OF STURTEVANT ENGINE.

4 in. dia. Forged steel is used for both the connecting-rods and crossheads, and the shaft is also forged in one piece. An oil tank upon each end of the cylinder casting is provided with individual sight feed oilers and connections to the various bearings. The engine is rated at 60 H. P. at 625 revolutions. On an extension of the engine shaft, with coupling between, the armature of the dynamo is carried, and the outer bearing is of the special ring-oiler pattern.

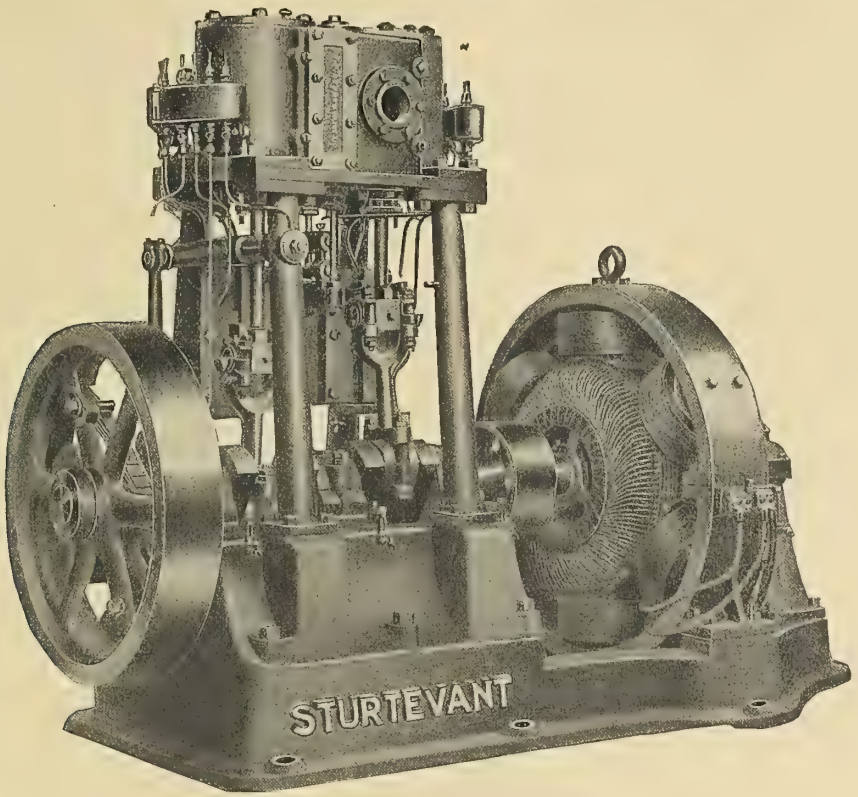
The field ring of the generator is of cast steel with wrought-iron pole pieces and cast-iron shoes. The armature is of the barrel-wound type, built up on spiders and with cast-iron flanges bolted thereto, forming supports as well as cylindrical receptacles for the projecting ends of the coils, and also protecting them from any oil that may be thrown. The interior surface of the armature is perfectly smooth, offering no opportunity for the collection of oil or dust. Ventilation is effected by the use of specially constructed veins, forming air ducts between the laminae of the coil, thus converting the armature into a blower, and creating a strong draft through the windings. The brushes are of the reaction type, and when properly set insure sparkless operation under all changes from no load to 25 per cent overload. The temperature rise after ten hours' full load run is limited to 90 deg. For the illustrations here printed we are indebted to our contemporary *Power*. Additional particulars can be had from the manufacturers, the B. F. Sturtevant Co., Jamaica Plain, Mass.

Portable Air Compressor.

Our illustration shows a 12 horse power Fairbanks-Morse gasoline air compressor, which is mounted on an iron frame truck, the object being to make it a portable outfit which could be conveniently moved about for field work. The outfit is mounted complete with all accessories; two tanks are provided for cooling water, one for each cylinder. The air receiver is suspended under the frame and a tank for gasoline is suspended at the back of the truck.

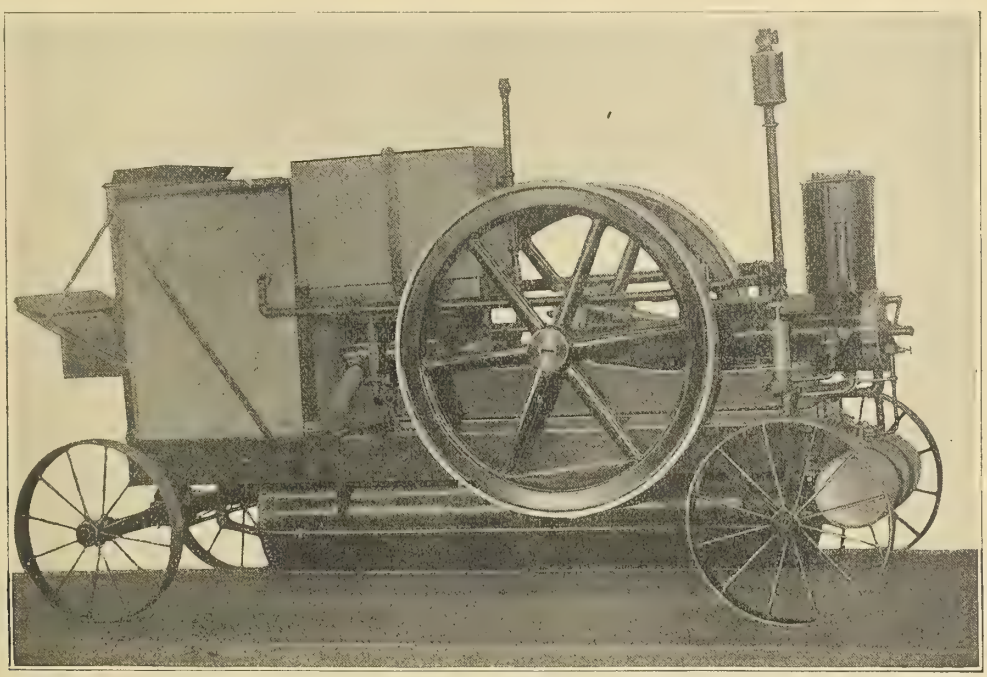
This compressor, like the standard stationary combination, is fitted with a mechanical unloading de-

vice by which a constant pressure is maintained in the air receiver tank. An electric igniter is used for firing the charge in the cylinder, and a self-starting device is provided for setting the engine in motion.



STURTEVANT GENERATING SET.

With a truck arranged as illustrated, with broad wheels, the outfit can easily be pulled about by a team of horses. One of these outfits was furnished to the Cleveland Shipbuilding Co., Lorain, O. In a large yard or for repair work, which has often to be done remote from the shops, the value of this outfit will be readily appreciated by builders. It is made by Fairbanks, Morse & Co., Chicago, Ill.



FAIRBANKS-MORSE PORTABLE AIR COMPRESSOR.

MARINE ENGINEERING

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AN effect of the Spanish war has been to forcibly direct the attention of foreign nations to the influence of America as a sea power, not merely naval, but mercantile. This has been made manifest by the frequent articles and observations lately printed in foreign papers bearing on the subject. Prior to the war the interest of foreigners in this expression of our national energy was languid. They knew that ships could be and were built here, but those in the foreign trade were not numerous; the American flag was a stranger to many ports and infrequently seen in any. The marine activities of other nations were ever present, and very naturally the objects in view received more attention than those remote. Manila and Santiago had a seismic effect, however, and now the leading maritime nations are standing around wondering what will happen next. From professional engineering circles abroad, especially British, comes the admission, given condescendingly, that very probably the American people will be able to build up a merchant marine and get their share of the carrying trade. Well, the American people can do it, and will do it, and when they have finished a good many ship owners and, probably, shipbuilders abroad will have gone out of business. The foreign capitalist, who looks at the subject with no professional bias, appreciates the situation more fully than the engineer. His opinions are voiced in an important article published recently in the *Statist* of London, and reproduced in this issue on another page. This notes the great national desire for an adequate merchant marine, and the present conditions in the steel trade, which permit the production of high-grade material as cheap or cheaper than it can be made abroad. There are indications even now of a great awakening in shipping circles here. Shipyards on the coast are filled with orders, and new plants which but recently were either inactive or not in existence are now engaged in turning out steam tonnage. A rough estimate of the amount of work of all kinds in the shipyards of the country places it at nearly half a million tons, of a money value away up in the millions. These, however, are simply evidences of the spirit which prevails and which will finally place this country in its proper position as a maritime nation. There is much to be done yet in the way of legislation, in interesting capital in shipping, and in the proper equipment of yards, so that work can be done economically, enabling the builder to make competitive prices and a profit at the same time. Business conditions are favorable to an early expansion of the merchant marine; new possessions have been acquired, and, of probably greater mercantile importance, manufacturers of all sorts of wares are successfully reaching after foreign trade as never before. When such trade reaches sufficient proportions indirect shipments, which are now made to many ports, will no longer be profitable, and direct lines will result. There is a tremendous amount of work to be done, however, before these much-desired results are obtained and America heads the list in merchant marine tonnage. Every one who is interested can help the movement along by personal exertion, no matter in how limited a sense. There is now no greater humiliation possible to an American than to visit any of our principal seaports and note the invariable absence of the American flag and the presence of foreign flags on steam tonnage in the foreign trade. Thousands of tons of shipping are added yearly to lines trading between American and foreign ports, and the proportion owned and operated by Americans is practically nothing. Even in the vitally important and profitable transatlantic trade the amount of real American tonnage is pitifully small.

ONE of those fortunate accidents which recall the saying that everything that happens is for the best occurred at the Navy Yard in New

York on the night of February 15, and resulted in the destruction of the machine shop by fire. After the members of the engineering staff and all the workmen had gone home fire broke out, from causes unknown, in the upper portion of the building, and though details of sailors and the city fire department did very effective work the building was ruined. But for this speedy and unexpected removal the shop would be now, and for how long in the future no one knows, a monumental disgrace to the most important Naval station in the country. A more unsuitable or inconvenient building for such a purpose it would be hard to design: if we mistake not it was originally intended for a textile factory. It was L-shaped and storied, dark and depressing, and altogether out of date. Then too there was a wonderful collection of antiquated tools within its walls. It is, of course, a matter of congratulation that the fire did not occur during the late war, when a tremendous amount of work was turned out there, and that in a hurry too. Now, however, there is opportunity to take time to replace the old shop with a thoroughly modern structure, in which questions of hygiene, shop management, which includes a proper disposition of machines, and adequate accommodation for the executive staff will be well considered and worked out. A thoroughly modern equipment of modern machine tools and apparatus for economically handling work goes without saying. It should be a matter of pride with those concerned to have a shop that would be adequate for the future needs of the Navy, and that would serve as a model for private shops to copy with advantage. The Navy has done so much for the country in raising the standard of quality of material that it could, now that the opportunity is at hand, create a new standard in machine-shop design and equipment.

IN the course of a debate in the House recently Mr. Bromwell, of Ohio, proposed that one of the new war vessels be named "The American Boy," and a number of very unsentimental gentlemen opposed him. It would be of passing interest to know how many of these members had familiar experience with the American boy in their homes. As to the proposition, however, it was one for which the Navy Department will be devoutly thankful, seeing that the list of States is limited, and naval heroes' names are being rapidly exhausted in giving identity to our torpedo boats and destroyers. The name of a ship is a matter of great consequence, and we therefore timidly venture a few suggestions. In some way the ship should be typical—a great opportunity for the designer to show his sense of the fitness of things. (Here we are in doubt whether "The American Boy" should be referred to as "he" or "she." Usage decides in favor of "she.") Well (his?), her figurehead should display a red Indian in full war paint, and she should be supplied with a syren of special pattern that would let out a regular Comanche war whoop in time of trouble. Then she should be chock full of guns, all rapid-fire, and should carry an extra supply of ammunition so as to be able to fire often and fire fast. There would be no doubt of her popularity among Young America; did she but touch at any of our ports the public schools would be closed, for no American boy could be expected to pay attention to the three Rs when his namesake was in port. There would be this drawback about the name, that when the vessel came of age her (his?) name would have to be changed to "The American Man," and then the change of name would call for an appropriate change of appearance, such as a lengthening or broadening out, or the substitution for the matured vessel of a larger and more powerful ship. Though the name would be very good for a starter we believe that it is too general to be altogether satisfying. Would not it be better to build a "Boy" class, just as the British have an "Admiral" class, for example? Then distinctive types of "Boy" could be properly represented; or, better still, use the "Boy" to distinguish the type of vessel so named. For instance, "The Butcher Boy" would be an appropriate name for one of those fat, dumpy monitors that would have a slow, steady gait. Then "The Newsboy" would call to mind a diminutive, smart little gunboat, quick in its movements, that could scrap on the least provocation and stand any amount of hard knocks. Then for a really slow, vacillating sort of vessel, say of the collier type, what name could be more suitable than "The District Messenger Boy?" She would live up to her reputation of getting to any point when she was good and ready. "The Good Boy" should be fitted with twin rudders, and be warranted to get in and out of New York harbor without grounding; and "The Bad Boy"—well, no hostile commander could risk an engagement when he was around. "The Tomboy" would be a saucy little cruiser that could always ship a crew. Space does not allow further examples, though they are numerous, but the foregoing we respectfully submit to the Committee on Naval Affairs.

BRITISH VIEW OF THE FUTURE OF AMERICAN SHIPBUILDING AND SHIPPING.

Perhaps the most important economic question of our time is connected with the development of the iron and steel industries of the United States and the probable consequences of that development, not only on the cognate industries of Europe, but also on the whole maritime relations of the commercial world, says the *Statist*, London's financial authority. In the palmy days of the proud wooden "clippers," the Americans had the bulk of the transatlantic carrying trade and the best of the carrying trade between Great Britain and China and Australia. Their wooden vessels were not only things of beauty, but were, with national ingenuity, constructed so as to combine high speed with the largest possible cargo capacity, and with every possible contrivance for saving labor. We are, indeed, apt to forget that America once divided with us the world's carrying trade, if, indeed, for a time she did not have the lion's share. It is only since the age of iron that she has lost that position; though she need not have lost it had not the fiscal policy that has developed since the civil war prevented her both from importing material wherewith to build ships at a profit, and also from buying ships from foreigners, except under practically prohibitive conditions. And now we are face to face with two momentous facts that presage a revolution in the world's shipping and a formidable competitor with Great Britain as the world's common carrier. These facts are (1) that the people of the United States have now become impatient of their stifling navigation laws, and are craving for a national merchant navy; and (2) that now, for the first time in their history (since the decline of the wooden ships), are the Americans able to produce shipping material on a level with Great Britain.

It is probable that Congress will soon revise, if not repeal, the navigation laws. Leaving, however, the fiscal aspects of the question for the present, we propose to take a rapid view of America as an actual iron and steel producer and as a prospective builder of high-class modern iron and steel vessels.

In the first place, we have to note that the States have not yet reached their maximum power in the production of pig iron. Their furnaces are much larger than ours, and their proportion of obsolete types must be small, indeed, compared with the number of antique examples we have still standing in England, Scotland and Wales. At any rate, their existing furnaces are computed to have a capacity of over a million tons per month. The actual production has not yet reached that capacity, and there is, of course, no limit but that of capital to the number of new furnaces which may yet be built. Can such enormous quantities be produced as cheaply as in Britain? The truth seems to be that in the more favorably situated works of the United States, and with the more economically worked furnaces (which are three or four times the size of ours), the prime cost of American pigs is below that of either Scotland, Cleveland or Cumberland in the respective qualities. This is a point on which we must speak with some diffidence, as it is a matter for industrial experts, and we by no means accept the shipments of American pigs to England as evidence of profitable business. But experienced iron manufacturers with whom we have conversed have expressed their belief that the southern States of America, and those of the northern States that are within easy reach of the lake ore, can certainly smelt pigs more cheaply than we can. It is enough if they can do it as cheaply, when we pass to the next stage of competition.

And in all stages the Americans have the advantage of cheaper fuel. Barring India, American coal is now the cheapest in the world, and on the average is to the industrial consumer fully 6 cents per ton cheaper than the average in England, Scotland and Wales. This is an advantage, of course, that tells at every stage of manufacture. It is also a noteworthy fact that wages in the American iron industry have been materially reduced of late years, while the producing capacity has also increased. The eight-hour movement is unknown in the States and the continuity of energy is one of the great factors in American industrial development. To take one example: At the Pennsylvania blast furnaces, in 1880, the wage cost was about $2.50 per ton of pig iron. By 1890 the wage cost was reduced to $1.25, and now it has been pretty generally reduced to about 50 cents per ton. Again, the average annual output per employee was, in 1880, 190 tons. It is now about 550 tons. These facts speak for themselves, and those who run can read their significance.

Now, take another fact in relation to the American iron industry. Until within recent years that industry practically depended on the development of the railway systems of the States. When railway building was slack the iron industry was depressed, and vice versa. But of late years, while railway building has shrunk to insignificant proportions, the production of all kinds of iron and steel has enormously increased. Look at the following figures:

Year.	Mileage of New Railroad Built. Tons.	Output of Pig Iron. Tons.	Output of Finished Iron and Steel. Tons.
1882	11,500	4,623,323	3,500,000
1887	13,000	6,417,148	5,250,000
1897	1,880	9,652,680	7,000,000

Of course, this means that producers of American iron and steel have found new and larger outlets for their material in other industries than railway building.

One outlet may now be accounted the making of steel rails for export. For American steel rails are now being supplied on contract to British India, Russian Asia (the Trans-Siberian line), the West Indies, Nova Scotia and Canada generally, South Africa, Hawaii, and even Ireland. In one month last year the two largest steel rail companies are said to have booked between them no less than half a million tons, the larger proportion of which was for export. Nor is this surprising, for prices in America (under the stress of constantly expanding competition) have been coming down as they have been going up in Europe. Thus, in 1896, the price of steel rails was $25 per ton in the United States, $27.50 in Germany, and $24.34 in Great Britain. In 1898 the current prices were $19.50 in the United States, $29.34 in Germany, and $23.12 in Great Britain. The reduction in America is not due to competition alone, but largely to the reduced cost of material and greater economy in production.

It is, of course, the reduced cost of production that has given America a chance in foreign markets that she never had before. The surplus of many American manufacturers has been often enough "dumped" into foreign countries—especially Canada—in order to relieve the home markets. But the business now being done by Americans in iron and steel cannot be regarded as of the "dumping" character. They are cultivating an export trade, and with such success that in the year ending June 30 last the exports of raw and manufactured iron and steel amounted to $70,367,527, as against $57,497,872 in the previous year. These exports consisted of 235,868 tons of pig iron, 232,552 tons of railway iron, 64,745 tons of iron wire, 60,195 tons of scrap iron, 30,585 tons of structural iron and 16,100 tons of steel billets and ingots. The total quantity of all sorts sent to Great Britain was 150,000 tons, and nearly all the rest was sent to countries accustomed hitherto to buy from us. In the nine months ending September 30 the exports of steel rails amounted to 222,973 tons, valued at $4,465,087. These figures compare with 88,573 tons and $1,891,724 in the corresponding portion of 1897, and with 50,841 tons and $1,189,106 in the corresponding part of 1896.

The largest buyers of the increased quantity have been Canada and Japan; and it is well to remember

that it was stated in Parliament last session that the lowest tenders for rails for the supply of the Indian railways were American. As to Japan, which used to get all her rails from us, we note the following in a special report by Mr. Lyon, United States Consul at Hiogo:

"In 1896 the United States exported to Japan only a little more than one-sixth as much railway iron as England did; but in 1897 a very notable increase took place from the United States in such shipments, and exportations from the two countries stood thus: Great Britain, $810,091; United States, $625,083. At this rate another year will show the United States to have left its competitor in this export far behind."

That may or may not be; but the enormous advantage possessed by the United States in the coming market for railway iron in China is an important factor in the development of production now taking place. That development has gone on to steel ship plates, which are now being shipped to this country for shipbuilding.

The point we have sought to bring out is that America has now so developed her iron and steel industries that she must find fresh outlets for her products. Such outlets she is finding, as we believe with profit, in foreign markets for certain products. For other products, however, she will need to create a new shipbuilding industry of her own; and what has been done or is being done in that connection we must reserve for future examination. No thoughtful man, acquainted with the American character, who considers the situation, can fail to perceive that the greatest competition to be faced by British industry and enterprise in the future is that of American shipbuilding. It may be deferred a few years, but it is bound to come.

Wages on British and American Steamships.

To give our readers an idea of the rate of wages paid on oil tank steamers under the British and American flags, says the *American Shipbuilder*, we obtained the following facts: The Alleghany, as will be remembered, was wrecked in these waters and afterward became the property of Lewis Luckenbach, 129 Broad street, New York. She was extensively overhauled by Neafie & Levy, and is now in the transatlantic oil trade, having left this port January 18, bound for Dover, England, for orders. She will return in ballast. The wages paid the crew are as follows, under the two flags:

American.		British.	
Captain,	$125	Captain,	$100.00
1st Officer,	75	1st Officer,	47.50
2d Officer,	60	2d Officer,	35.00
Chief Eng.,	125	Chief Eng.,	90.00
1st Asst.,	70	2d Eng.,	60.00
2d Asst.,	60	3d Eng.,	35.00
2 Oilers,	40 each.	2 "Greasers,"	25.00 each.
Steward,	40	Steward,	30.00
Cook,	35	Cook,	26.50
8 Sailors,	25 each.	6 Sailors,	20.00 each.
6 Firemen,	35 each.	8 Firemen,	21.50 each.
2 Coal passers,	30 each.		

The above table shows that the Alleghany cost $764 per month under the British flag and $1,140 per month under the American flag, for wages alone, making a total of $4,512 per year in favor of the British ship. The Alleghany carries 26 men, under the American flag, which is two more than she carried under the British flag. This ship burns 22 tons of coal per day, making a speed of 11 knots. The food is much better (and consequently costs more) on American steamships than on British, although there is little, if any, difference in the food given to sailors on sailing ships under the British or American flags. The dimensions of the Alleghany are: Length, 320 ft.; beam, depth, 19.2 ft.; British tonnage, net, 1,911; gross, 2,914. Tonnage under the American flag, 1,889 net, 3,009 gross; engines, triple-expansion, 25, 40 and 66 in. by 45 in. stroke. The vessel was built by Craig, Taylor & Co., in 1890, at Stockton, England.

EDUCATIONAL DEPARTMENT.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—VI.

BY DR. WILLIAM FREDERICK DURAND.

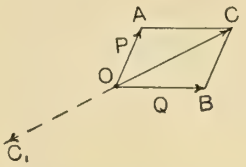
[12] Propositions in Statics.

Following are a few simple propositions in statics given without proof.

(1) A force may be transferred along its line of action without changing its effect.

(2) Two forces equal and directly opposite will balance or produce equilibrium.

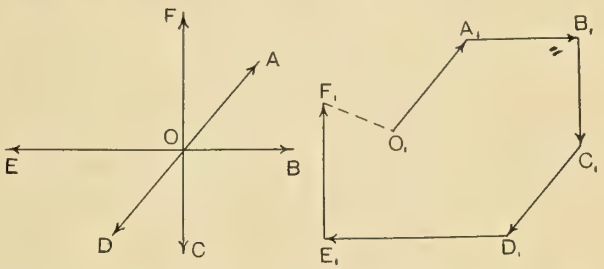
(3) Parallelogram of Forces. If two forces whose lines of action meet in a point O are represented in amount and direction by the lines $O\ A$ and $O\ B$, then



will the resultant of these two forces be represented also in amount and direction by the diagonal $O\ C$ of the parallelogram $O\ A\ C\ B$ erected on $O\ A$ and $O\ B$ as adjacent sides.

(4) A force $O\ C$, represented by the diagonal $O\ C$ reversed will balance $O\ C$ or R, and therefore will balance P and Q.

(5) Polygon of Forces. Let there be a system of forces represented as in (a). In (b) starting at any point O draw $O\ A_1$ equal and parallel to $O\ A$. Then from A_1 as starting point draw $A_1\ B_1$ equal and parallel to $O\ B$, and so on, drawing finally $E_1\ F_1$ equal and parallel to

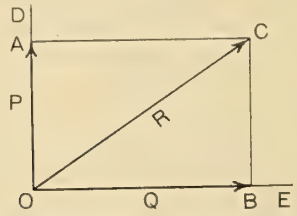


$O\ F$. Then will the closing line $O\ F_1$ in direction and amount represent the resultant of the system of forces, while $O\ F_1$ reversed, or $F_1\ O$, will represent similarly the balancing force of the system—that is, the single force which will balance the system and with it produce equilibrium. In the construction in (b) the order in which the forces are taken is indifferent, but we have here supposed them taken in regular order to the right, beginning with $O\ A$ and ending with $O\ F$.

It is readily seen that this proposition is a generalization of (3) extended to cover the case of any system of forces. It follows from this proposition that if any system of forces may be represented as in (b) by the sides of a completely closed polygon, then such system will produce equilibrium, for the resultant in such case would be 0. Again in such case any force may be considered as the *balancing force* for the system composed of all the others, and any force reversed may be considered as the *resultant* of the system composed of all the others.

(6) Components. In the figure the two forces P and Q are at right angles. In such case they are known as the *components*, or, more correctly, the *rectangular*

components, of their resultant *R* along the lines *O D* and *O E*. In general the component *O B* of any force



O C along any line *O E* is found by drawing from *C* a line *C B* perpendicular to *O E*, thus determining the length *O B*.

(7) Conditions for Equilibrium. The conditions for the equilibrium of any body are as follows:

(a) The sum of all the components of all the forces acting on the body taken along any line, or more particularly along any pair of lines at right angles, must balance.

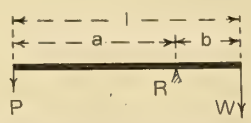
(b) Taking any point as origin, the sum of the moments of all the forces tending to turn the body in one direction about this origin must equal or balance the corresponding sum in the other direction.

If all the forces act at a single point, only the first of these conditions is necessary. If instead they act at different points of a body, both conditions are necessary.

[13] Mechanical Powers.

Lever. A lever consists essentially of a bar which supports a weight or applies a force at one point by means of a force applied at another point, the bar in the meantime being supported and turning about a third point called the fulcrum. According to the relation of these three points, levers are divided into three classes as below.

Lever of the First Class. In this the fulcrum *R* is between the points of application of the forces *P* and



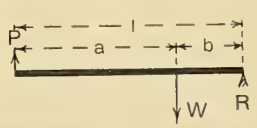
W. The following proportions and equations apply to this case:

$$\begin{array}{lll} P : W & :: b : a & \text{or} \quad P\,a = W\,b \\ P : P+W & :: b : l & \text{or} \quad P\,l = (P+W)\,b \\ W : P+W & :: a : l & \text{or} \quad W\,l = (P+W)\,a \end{array}$$

$$P = \frac{b}{a}\,W = \frac{b}{e}\,(P+W) \qquad a = \frac{W}{P}\,b = \frac{W}{P+W}\,l$$

$$W = \frac{a}{b}\,P = \frac{a}{l}\,(P+W) \qquad b = \frac{P}{W}\,a = \frac{P}{P+W}\,l$$

Lever of the Second Class. In this the weight lifted or resultant force *W* is between the applied



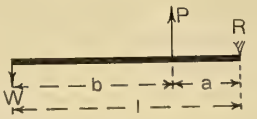
force *P* and the fulcrum *R*. The following proportions and equations apply in this case:

$$\begin{array}{lll} P : W & :: b : l & \text{or} \quad P\,l = W\,b \\ P : (W-P) & :: b : a & \text{or} \quad P\,a = (W-P)\,b \\ W : (W-P) & :: l : a & \text{or} \quad W\,a = (W-P)\,l \end{array}$$

$$P = \frac{b}{l}\,W = \frac{b}{a}\,(W-P) \qquad a \quad \frac{W-P}{P}\,b = \frac{W-P}{W}\,l$$

$$W = \frac{l}{b}\,P = \frac{l}{a}\,(W-P) \qquad b = \frac{P}{W}\,l = \frac{P}{W-P}\,a$$

Lever of the Third Class. In this the applied force *P* is between the weight lifted or resultant force



W and the fulcrum *R*. The following proportions and equations apply to this case:

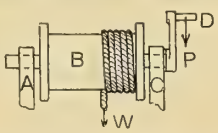
$$\begin{array}{lll} P : W & :: l : a & \text{or} \quad P\,a = W\,l \\ (P-W) : W & :: b : a & \text{or} \quad (P-W)\,a = W\,b \\ (P-W) : P & :: b : l & \text{or} \quad (P-W)\,l = P\,b \end{array}$$

$$P = \frac{l}{a}\,W = \frac{l}{b}\,(P-W) \qquad a = \frac{W}{P}\,l = \frac{W}{P-W}\,b$$

$$W = \frac{a}{l}\,P = \frac{a}{b}\,(P-W) \qquad b = \frac{P-W}{W}\,a = \frac{P-W}{P}\,b$$

An ordinary crowbar, a pair of scissors, an air pump lever, are all examples of a lever of the first class. A pair of nut crackers, an oar (the water being the fulcrum), and often many of the levers about the starting and drain gear of an engine, are examples of a lever of the second class. The forearm (the elbow being the fulcrum), or a ladder when raised against a house, are examples of a lever of the third class.

Windlass and Crank. In this device a barrel *B* is carried on an axle supported in bearings at *A* and *C*, and operated by a crank *D*. The weight *W* may then, by means of a rope wound on the barrel, be raised or

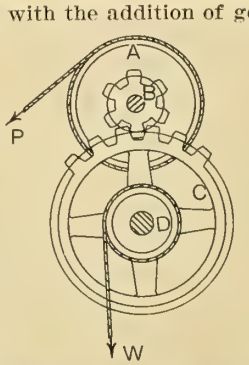


lowered by the action of a force *P* applied at the crank. The following proportions and equations give the relations between the various quantities concerned:

$$\begin{array}{lll} P : W :: r : R \text{ or } P\,R = W\,r \\ P & = \frac{r}{R}\,W & W = \frac{R}{r}\,P \\ r & = \frac{P}{W}\,R & R = \frac{W}{P}\,r \end{array}$$

r = radius of barrel.
R = radius of crank.

Geared Hoist. This device is similar to those of Figs. 53 and 54, with the addition of gearing between



the force *P* and the weight *W*. The following equations apply to this case:

$$\frac{P}{W} = \frac{r_1\,r_2}{R_1\,R_2}$$

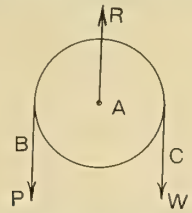
$$P = \frac{r_1\,r_2}{R_1\,R_2}\,W$$

$$W = \frac{R_1\,R_2}{r_1\,r_2}\,P$$

Most deck winches are illustrations of a simple geared hoist.

R_1 = radius of A
r_1 = radius of B
R_2 = radius of C
r_2 = radius of D

Single Fixed Pulley. A is a pulley or sheave supported from R and turning about its center. B C is a single rope led over the pulley, to one end of which the

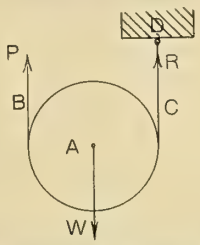


force P is applied, and to the other end of which the weight W is attached. The following equations apply to this case:

$$P = W$$
$$R = P + W = 2\,P$$
Velocity of W = velocity of P

A single whip used for raising light weights is an illustration of this purchase.

Single Movable Pulley. A is a pulley or sheave to the frame of which is attached the weight W. B C is the rope rove through the sheave, having one end

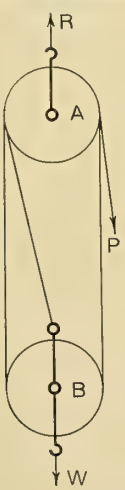


made fast to the support D, while to the other is applied the force P. The following equations apply to this case:

$$W = 2\,P$$
$$R = P = \frac{W}{2}$$
Velocity of W = 1-2 velocity of P

Tacks and sheets on light sails are illustrations of this form of purchase.

Luff Tackle. In this purchase there are two



sheaves at A and one at B, and the rope is led as shown. The following equations apply to this case:

$$W = 3\,P$$
$$R = 4\,P$$

If upper block is fixed,
Velocity of W = 1-3 velocity of P.
If lower block is fixed,
Velocity of R = 1-4 velocity of P.
In order to obtain the greatest advantage with this purchase, therefore, B should be the fixed block.

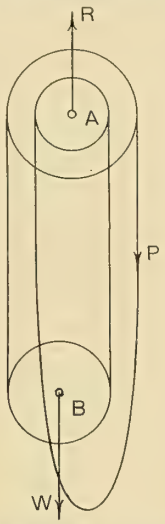
A Pair of Blocks, as in the Luff Tackle Figure, with Any Number of Sheaves in Either Block.

$\frac{W}{P}$ = total number of ropes at the lower block, passing through and attached.

$\frac{R}{P}$ = total number of ropes at the upper block, passing through and attached.

Thus in the figure the number of ropes at the lower block is 3 and at the upper block 4, which, according to the rule, would give the same relations between P R and W as in the equations above.

Differential Pulley. In this purchase there are two sheaves at A fastened together, or made in one



piece, and one sheave at B. A rope or chain is rove as shown in the figure, and the force is applied at P while the weight W is supported from the lower block. The following equations apply to this case:

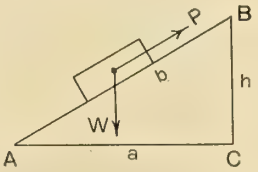
R = radius of larger upper pulley
r = radius of smaller upper pulley

$$\text{Then} \quad \frac{W}{P} = \frac{2\,R}{R - r}$$
$$\text{or} \quad W = \frac{2\,R}{R - r}\,P$$
$$\text{Velocity of } W = \frac{R - r}{2\,R} \text{ (velocity of } P)$$

The differential pulley is commonly found in all engineers' outfits on board ship.

Inclined Plane.

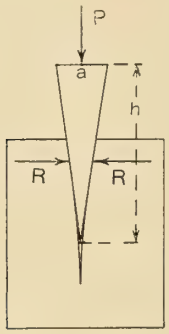
$$\frac{W}{P} = \frac{b}{h} \quad \text{or} \quad W = \frac{b}{h}\,P$$



$$\text{and } P = \frac{h}{b}\,W$$

WEDGE.

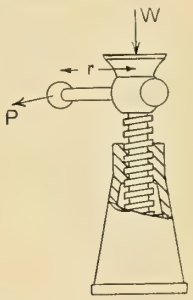
$$\frac{R}{P} = \frac{h}{a} \text{ or } R = \frac{h}{a} P$$



and $P = \frac{a}{h} R$

SCREW.

p = pitch of screw
P = force applied at radius r
W = pressure exerted



$$P : W :: p : 2\pi r$$
$$\text{or } P : W :: p : 6.2832\, r$$
$$\text{or } W = \frac{6.2832\, r}{p} P$$
$$P = \frac{p}{6.2832\, r} W$$

Examples of the applications of the three last figures will be too familiar to need special mention.

Examples in Mechanics.

We give below the solutions of a few simple examples as illustrations of the preceding principles of mechanics. In all cases the effects of friction are omitted.

(1) In a lever of the first class as shown, $a = 48$ and $b = 8$. With a pull P of 160 lb., what weight W can be raised?

$$W = \frac{a}{b} P = \frac{48}{8} \times 160 = 960 \text{ lb.}$$

(2) In a lever of the second class as shown, $l = 72''$ and $b = 12''$. What force P will be required to raise a weight W of 600 lb.?

$$P = \frac{b}{l} W = \frac{12}{72} \times 600 = 100 \text{ lb.}$$

(3) In a lever of the third class as shown, $l = 40''$ and $W = 30$ lb. Where must a force P of 80 lb. be located so as to maintain equilibrium?

$$a = \frac{W}{P} l = \frac{30}{80} \times 40 = 15''$$

(4) The dimensions of a windlass and crank as illustrated are as follows: Radius of crank = 14 ". Radius of barrel = 4 1-2 ". What weight can be raised with a force of 60 lb. applied at the crank?

$$W = \frac{R}{r} P = \frac{14}{4\frac{1}{2}} \times 60 = 186\ 2\text{-}3 \text{ lb.}$$

(5) With a wheel and axle as illustrated, the diameter of the wheel is 6 ′ and of the axle 10 ". What force P will be required to hoist a weight W of 600 lb.?

$$P = \frac{r}{R} W = \frac{5}{36} \times 600 = 83\ 1\text{-}3 \text{ lb.}$$

(6) The dimensions of a geared hoist as illustrated are as follows: Diam. of $A = 24''$; number of teeth in $B = 16$; number of teeth in $C = 96$; diam. of $D = 10''$. What weight W can be hoisted if $P = 100$ lb.?

Since the diameters and radii of wheels are in the same ratio as their numbers of teeth, we have:

$$W = \frac{R_1 R_2}{r_1 r_2} P = \frac{12 \times 48 \times 100}{8 \times 5} = 1440 \text{ lb.}$$

(7) With a single movable pulley as illustrated, what weight can be raised with a pull P of 90 lb.?

$$W = 2P = 2 \times 90 = 180$$

(8) With a purchase as illustrated, what force P will be required to raise a weight W of 372 lb., and what will be the load at R?

$$W = 3P \text{ or } P = W \div 3 = 372 \div 3 = 124$$
$$R = 4P = 4 \times 124 = 496$$

(9) The dimensions of a differential pulley as illustrated are as follows: Larger diameter, 13 "; smaller diameter, 11". With a pull P of 80 lb., what weight W can be raised?

$$W = \frac{2R}{R - r} P = \frac{2 \times 6\frac{1}{2} \times 80}{6\frac{1}{2} - 5\frac{1}{2}} = 1040 \text{ lb.}$$

(10) An inclined plane as illustrated has dimensions as follows: Slant length, $b = 72''$; height, $h = 18''$. With a pull P of 40 lb., what weight W can be moved up the plane?

$$W = \frac{b}{h} P = \frac{72}{18} \times 40 = 160 \text{ lb.}$$

(11) A wedge as illustrated has the following dimensions: Back, $a = 4''$; length, $h = 26''$. What resistance R can be overcome by a force P of 216 lb.?

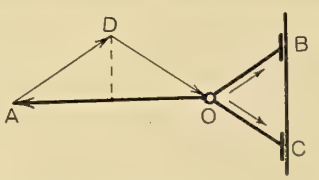
$$R = \frac{h}{a} P = \frac{26}{4} \times 216 = 1404 \text{ lb.}$$

(12) A screw as illustrated has the following dimensions: Pitch $p = 1\text{-}4''$; radius $r = 12''$; force $P = 60$ lb. What pressure W can be exerted?

$$W = \frac{6.2832 \times 12 \times 60}{\frac{1}{4}} = 18095.6$$

(13) Given a boiler brace $O\ A$ with crowfoot or forked attachment to the plate $B\ C$. With a known load on $O\ A$, required the load on $O\ B$ and $O\ C$.

Evidently the three forces on $O\ A$, $O\ B$ and $O\ C$ keep the joint O in equilibrium. If represented according to

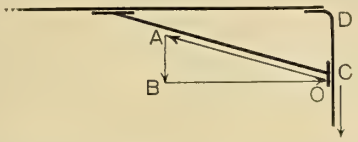


the polygon of forces [12] (5), they must form a closed triangle. This is represented by $O\ A\ D$, where $O\ A$ represents the force on the brace, $A\ D$ that on $O\ B$ and $D\ O$ that on $O\ C$. Hence if $C\ A$ is laid down to some convenient scale to represent the load on the brace, then $A\ D$ and $D\ O$ respectively will, according to the same scale, represent the loads on $O\ B$ and $O\ C$.

(14) Given a boiler brace $O\ A$ oblique to the shell $C\ D$. With a known load in the direction $B\ O$, required the load on $O\ A$.

The point of attachment O is again maintained in equilibrium by the action of the three forces, one along

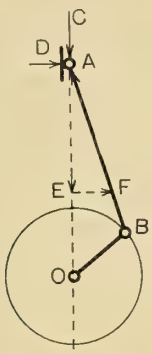
O A, one in the direction *B O*, and a third *O C* existing as a tension in the plate. The triangle of forces in this case is represented by *O B A*. Hence if *O B* is laid off



to any scale to represent the known load, then will *O A* represent to the same scale the resulting load on the brace.

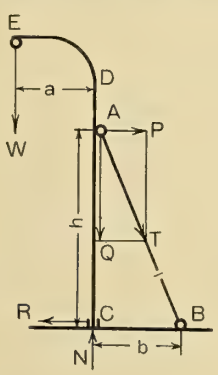
(15) Let *C A B O* represent the moving parts of an engine. With a known piston load acting along *C A*, required the resultant loads on the connecting rod and on the guide.

The point *A* is kept in equilibrium by the action of the three forces, one acting down along *C A*, one acting up the rod along *B A* and one acting from the guide



along *D A*. It is the two latter which are required. The triangle of forces in this case is represented by *A E F*. Hence if *A E* is laid off to represent to any convenient scale the known piston load, then to the same scale will *A F* and *E F* represent the loads on the connecting rod and crosshead respectively. It thus appears that the load on the connecting rod is in general greater than that on the piston rod, and that it is greater in the same ratio that any length *A F* is greater than the corresponding distance *A E*.

(16) Let the diagram represent a davit *C D* supporting a weight *W* and braced by a stay *A B*. With a



given weight *W*, required the tension on the stay and the forces at the foot of the davit.

The tension *T* may be represented by its two components *P* and *Q*, and the reaction at *C* by two components *N* and *R*. In this case we require the use of both conditions of equilibrium, and without giving all details we will simply write the equations and the resulting values of the forces.

Equating vertical forces $W + Q = N$

Equating horizontal forces $P = R$

Taking movements about *C* $W a = P h$

We have also $P = \frac{b}{l} T$

and $Q = \frac{h}{l} T$

From these equations we find:

$$P = \frac{a}{h} W$$

$$Q = \frac{a}{b} W$$

$$T = \frac{l}{b} \frac{a}{h} W$$

$$R = \frac{a}{h} W$$

$$N = \left(\frac{a + b}{b}\right) W$$

(Concluded.)

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—MATERIALS OF ENGINEERING CONSTRUCTION—I.

BY DR. WILLIAM FREDERICK DURAND.

§1. ALUMINUM.

The commercially pure metal, i. e., with less than 1 per cent impurity, is white in color, soft, ductile, and malleable. It melts at about 1,160° F., has a tensile strength of about 15,000 lb. per square inch of section, but lacks in stiffness and *resilience*, or the power to withstand shocks.

Aluminum does not oxidize readily under the influence of ordinary air, but when in contact with sea-water, or in air charged with sea-water, the corrosion is often serious in extent. Aluminum cannot be welded except electrically, is not suitable for forging or rolling when hot, and cannot be tempered or hardened. It is, however, suitable for casting, and when cold can be rolled into sheets and drawn into wire, and in thin sheets or small pieces may be spun or flanged, or worked under the hammer in various ways.

Aluminum unalloyed is of comparatively small value to the engineer, but it enters into several valuable alloys as described in Section 9, and its use in this way has increased to a considerable extent within the past few years.

§2. ANTIMONY.

The pure metal is whitish in color, quite brittle and crystalline or laminated in structure, and has a melting point of about 840° F. It is useless in the pure state for ordinary engineering purposes, but is a valuable ingredient of various alloys used for bearing metals, etc., as described in Section 9.

§3. BISMUTH.

The pure metal is light red in color, very brittle and highly crystalline in structure, with a melting point of about 510° F. It is useless in the pure state for engineering purposes, but forms a part of various alloys used for bearing metals, etc., as described in Section 9.

§4. COPPER.

In the pure state the metal is red in color, soft, ductile, and malleable, with a melting point of about 2,000° F., and a tensile strength of from 20,000 to 30,000 lb. per square inch of section. Copper is not readily welded except electrically, but, on the other hand, is readily joined by the operation of brazing. Attempts have been made to temper or harden it, but the operation has not been made a practical success. It is readily forged and cast, and when cold may be rolled into

sheets or drawn into wire, and in sheets or small pieces may be spun or flanged or worked under the hammer in various ways.

The tensile strength of copper rapidly falls off as the temperature rises above about 400° F., so that at from 800° to 900° the strength is only about one-half what it is at ordinary temperatures. This peculiarity of copper should be borne in mind when it is used in places where the temperature is liable to rise to these figures. Again, if copper is raised nearly to its melting point in contact with the air it readily unites with oxygen and loses its strength in large degree, becoming when cool crumbly and brittle. Copper in this condition is said to have been *burned*. The possibility of thus injuring the tenacity of copper is of the highest importance in connection with the use of brazed joints in steam pipes.

In the operation of brazing a joint, the surfaces to be joined are cleaned, bound together with wire or otherwise, then supplied with brazing solder in small bits mixed with borax as a flux, and placed in a clear fire until the solder melts and forms the joint. The brazing solder, or *hard solder*, as it is often called, is usually a brass or alloy of copper and zinc. The melting point of all such alloys is below that of copper, and when copper is joined to brass, or two pieces of brass are joined together, the solder used must have a melting point lower than either of these metals. In the operation of brazing a copper joint, therefore, the greatest care must be taken in the selection of a solder and in attention to the fire, so that there may be no danger of *burning* the copper, and thus endangering the quality of the metal in the joint.

Copper unalloyed is used chiefly for pipes and fittings, especially for junctions, elbows, bends, etc. For large sizes the material is made in sheets, bent and formed to the desired shape and brazed at the seams. Small sizes are either made by the same general process or from solid drawn pipe, which may be bent as desired after drawing. Copper is also largely used as the chief ingredient of the various brasses and bronzes, as described in Section 9.

§5. IRON AND STEEL.

Classification.

It will be convenient to give here a general classification of iron and steel products based on the methods of manufacture. The following is the classification used by Prof. J. B. Johnson in his text book on the *Materials of Construction*.

Iron and Steel.

MALLEABLE.

Wrought Iron.—Rolled or forged from a puddle ball; it contains slag and other impurities and cannot be hardened by sudden cooling.

Steel.—Rolled or forged from a cast ingot and free from slag and similar matter.

Soft Steel.—Will weld (with care), and cannot be hardened by sudden cooling. It is sometimes called *ingot iron*, and has the same uses as wrought iron.

Medium Steel.—Welds imperfectly except by electricity. Will not harden by sudden cooling.

Hard Steel.—Will not weld. Hardens by sudden cooling. Tool steel, etc.

SEMI-MALLEABLE.

Steel Castings.—Malleable metal cast into forms.

Malleable Cast Iron.—Non-malleable metal cast into forms, and then brought to a semi-malleable condition.

NON-MALLEABLE.

Cast Iron; Hard Cast Steel.—In describing these products at length we shall find it convenient to begin with cast iron.

[1] CAST IRON. This material consists of a mixture and combination of iron and carbon, with other substances in varying proportions.

(1) *Influence of Carbon.* In the molten condition the carbon is dissolved by the iron and held in solution just as ordinary salt is dissolved by water. The mixture or combination of the two elements is thus entirely uniform. The proportion of carbon which pure melted iron can thus dissolve and hold in solution is about 3 1-2 per cent. If *chromium* or *manganese* is present also, the capacity for carbon is much increased, while with silicon, on the other hand, the capacity for carbon is decreased. In the various grades of cast iron the proportion of carbon is usually found between 2 per cent and 4.5 per cent.

Now, when such a molten mixture cools and becomes solid, there is a tendency for a part of the carbon to be separated out and no longer remain in intimate combination with the iron. The carbon thus separated or precipitated out from the iron takes that form known as *graphite*, and collects together in very small flakes or scales. The carbon which remains in intimate combination with the iron is said to be *combined*, while that which is separated out is usually called *graphitic*.

The qualities of cast iron depend chiefly on the proportion of total carbon and on the relative proportions of combined and graphitic carbon.

With a high proportion of graphitic carbon the iron is soft and tough, with low tensile strength, and breaks with a coarse grained dark or grayish colored fracture. In fact the substance in this condition may be considered as nearly pure iron with fine flakes of graphite entangled and distributed through it, thus giving to the iron a spongy structure. The iron thus forms a kind of continuous mesh about the graphite, which decreases the strength by reason of the decrease of cross-sectional area actually occupied by the iron itself. Such irons are termed *gray*.

As the relative proportion of graphitic carbon decreases and that of combined carbon increases, the iron takes on new properties, becoming harder and more brittle. Its tensile strength also increases to a certain extent, and the fracture becomes fine grained or smooth and whiter in color. When these characteristics are pronounced the iron is said to be *white*. When about half the carbon is combined and half separates out as graphite, the effect is to produce a distribution of dark spots or points scattered over a whitish field. Such irons are said to be *mottled*.

In a general way with a large proportion of total carbon there is likely to be formed a considerable amount of graphitic carbon, and hence such irons are usually gray and soft. With a large proportion of carbon also the iron melts more readily and its fluidity is more pronounced. As the proportion of total carbon decreases the cast iron approaches gradually the condition of steel, whose properties will be discussed in a later paragraph.

Of the special ingredients in cast iron the *combined carbon* is the one of greatest importance. It is that chiefly which by uniting with the iron gives it new qualities, and the principal influence of other substances lies in the effect which they may have on the proportion of this ingredient. As between graphitic and combined carbon, the former does not affect the quality of the iron itself, but acts *physically* by affecting the structure of the casting; while the latter, by entering into combination with the iron, acts *chemically* and produces a new substance with different qualities. The following percentages of combined carbon are recommended for qualities of iron as indicated:

	Proportion of Combined Carbon.
Soft cast iron	.10 to .15 of one per cent.
Greatest tensile strength	about .45 of one per cent.
Greatest transverse strength	about .70 of one per cent.
Greatest crushing strength	one per cent or over.

The proportions of combined and graphitic carbon are influenced by the rate of cooling, and by the presence or absence of various other ingredients. Slow cooling allows time for the separation of the carbon and thus tends to form graphitic carbon and soft gray irons. Quick cooling, or *chilling* in the extreme case,

prevents the formation of graphitic carbon and thus tends to form hard, white irons.

In addition to *carbon*, small quantities of *silicon, sulphur, phosphorus, manganese* and *chromium* may be found in cast iron.

(2) *Influence of Silicon.* The fundamental influences of silicon are two. (a) It tends to expel the carbon from the combined state and thus to decrease the relative proportion of combined carbon and increase that of graphitic carbon. (b) Of itself silicon tends to harden cast iron and to make it brittle.

These two influences are opposite in character, since an increase in graphitic carbon softens the iron. In usual cases the net result is a softening of the iron, an increase in fluidity, and a general change toward those qualities possessed by iron with a high proportion of graphitic carbon. This applies with a proportion of silicon from 2 per cent to 4 per cent. With more than this the influence on the carbon is but slight and the result on the iron is to decrease the strength and toughness, giving a hard but brittle and weak grade of iron.

A *chilled* cast iron is an iron which if cooled slowly would be gray and soft, but, as explained in (1), by sudden cooling, from contact with a metal mould or other means, becomes white and hard, especially at and near the surface. Certain grades of cast iron tend to chill when cast in sand moulds. This property is usually undesirable. In such cases the tendency can be prevented by the addition of silicon, which, by forcing the carbon into the graphitic state on cooling, prevents the formation of the hard, chilled surface. In all cases the actual effect of adding silicon will depend much on the character of the iron used as a base, and only a statement of the general tendencies can here be given.

To sum up, a white iron which would give hard, brittle and porous castings can be made solid, softer and tougher by the addition of silicon to perhaps 2 per cent to 3 per cent. As the silicon is increased the iron will become softer and grayer and the tensile strength will decrease. At the same time the shrinkage will decrease, at least for a time, though it may increase again with large excess of silicon. The softening and toughening influence, however, will only continue so long as additional graphite is formed, and when most of the carbon is brought into this state the maximum effect has been produced, and any further addition of silicon will decrease both strength and toughness.

(3) *Influence of Sulphur.* Authorities are not in entire agreement as to the influence of sulphur on cast iron, some believing that it tends to increase the proportion of combined carbon, while others maintain that it tends to decrease both the combined carbon and silicon. It is generally agreed, however, that in proportions greater than about .15 to .20 of 1 per cent it increases the shrinkage and the tendency to chill, and decreases the strength. Sulphur does not, however, readily enter cast iron under ordinary conditions, and its influence is not especially feared. An increase in the proportion of sulphur in cast iron is most likely to result from an absorption of sulphur in the coke during the operation of melting in the cupola.

(4) *Influence of Manganese.* This element by itself decreases fluidity, increases shrinkage, and makes the iron harder and more brittle. It combines with iron in all proportions. With manganese less than one-half, the combination is usually called *spiegeleisen.* With manganese more than one-half it is called *ferromanganese.* One of the most important properties of manganese in combination with iron is that it increases the capacity of the iron for carbon. Pure iron will only take about 3 1-2 per cent of carbon, while with the addition of manganese the proportion may rise to 6 per cent or 7 per cent. Manganese is also believed to decrease the capacity of iron for sulphur, and to this extent may be a desirable ingredient in proportions not exceeding 1 per cent to 1 1-2 per cent.

(5) *Influence of Chromium.* This substance is rarely found in cast iron, but it has the property, when present in large proportion, of raising the capacity of the iron for carbon from about 3 1-2 per cent up to about 12 per cent.

(6) *Shrinkage of Cast Iron.* At the moment of hardening, cast iron expands and takes a good impression of the mould. In the gradual cooling after setting, however, the metal contracts, so that on the whole there is a shrinkage of about 1-8 in. per foot in all directions, though this amount varies somewhat with the quality of the iron and with the form and dimensions of the pattern. In a general way hardness and shrinkage increase and decrease together.

(7) *Strength and Hardness of Cast Iron.* The hardness of cast iron is chiefly dependent on the amount of combined carbon, as noted above in (1).

The strength is also chiefly dependent on the same ingredient. As shown in (1), the greatest crushing strength is obtained with sufficient combined carbon to make a rather hard, white iron, while for the maximum transverse or bending strength the combined carbon is somewhat less and the iron only moderately hard, and for the greatest tensile strength the combined carbon is still less and the iron rather soft. Metal still softer than this grade works with the greatest facility, but is deficient in strength.

Numerical values for the strength will be given at a later point.

(8) *Uses of Cast Iron in Marine Engineering.* Cast iron is used for cylinders, cylinder heads, liners, slide valves, valve chests, and connections, and generally for all parts having considerable complexity of form. It is also used for columns, bed plates, bearing pedestals, caps, etc., though cast and forged steel are to some extent displacing cast iron for some of these items. It is also used for grate bars, furnace door frames, and minor boiler fittings, and for a great variety of special purposes usually connected with the stationary or supporting parts of machines.

(9) *Inspection of Castings.* In the inspection of castings care must be had to note the texture of the surface, and to this end the outer scale and burnt sand should be carefully removed by the use of brushes, or chipping hammer, or, if necessary, by pickling in dilute muriatic acid. The flaws most liable to occur are blow holes and shrinkage cracks. The latter, however, are not often met with when the moulding and casting are properly carried out. The parts of the casting most liable to be affected by blow holes are those on the upper side or near the top. On this account a sinking head or extra piece is often cast on top, into which the gases and impurities may collect. This is afterward cut off, leaving the sounder metal below.

The presence of blow holes, if large in size or in great number and near the surface, may often be determined by tapping with a hand hammer. The sound given out will serve to indicate to an experienced ear the probable character of the metal underneath.

(10) *Special Operations on Cast Iron.* Cast iron may be softened and toughened by the process of malleablizing, as described in [2]. It may be somewhat hardened on the surface by arresting the usual process of malleablizing at a suitable point and then hardening as for steel. This operation arrested before completion results in the formation of a surface layer of material having essentially the properties of steel.

Cast iron may be brazed to itself or to most of the common structural metals by the use of a brazing solder of suitable melting point, and with proper care in the operation. Cast iron may also be united to itself or to wrought iron or steel by the operation of burning. This consists in placing in position the two pieces to be united, and then allowing a stream of melted cast iron to flow over the surfaces to be joined, the adjacent parts being protected by fire clay or other suitable material. The result is to soften or partially melt the surfaces of the pieces, and by arresting the operation at the right moment they may be securely joined together.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE.—XVI.

BY WM. BAXTER, JR.

Switch Board Instruments.

The instruments commonly used upon switch boards are: switches, circuit breakers, ammeters, voltmeters, lightning arresters, safety fuses and field regulating rheostats. Of these the first named will demand our attention in the present article.

A switch, properly defined, is any device by means of which a current may be diverted into any circuit, or be cut off therefrom entirely. Switches may be divided according to the manner in which they are moved, and thus we would obtain side throw switches, plunger switches and vertical throw, or knife blade, switches. A side throw switch in its simplest form is shown in Figs. 70 and 71, the first being a top view

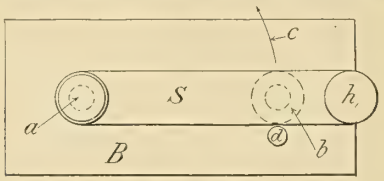


FIG. 70.

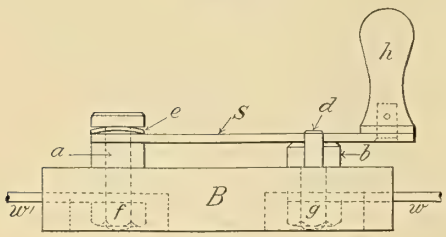


FIG. 71.

and the second a side elevation. In both these illustrations, *B* is the base, and it is made of hard wood or hard rubber for small sizes that are intended to transmit weak currents, and of slate or marble for those of larger capacity. The part marked *S* is the switch blade, and it is provided with a handle *h*, which latter is well insulated from other parts. The terminals of the line are connected with the studs *a* and *b*, as is shown in Fig. 71, where *w w* are the wires, which are firmly held by the nuts *f* and *g*.

Switches of this kind are generally arranged to move in one direction only, as is indicated by arrow *C*, and to prevent movement in the other direction the stop post *d* is provided. This construction is advantageous, as with it the switch can be closed rapidly without

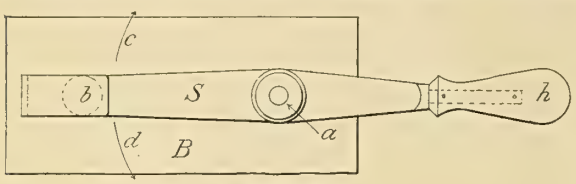


FIG. 72.

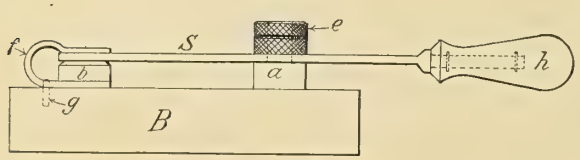


FIG. 73.

danger of swinging it beyond the closed position. In the illustrations the switch is shown closed, and in this position it can be seen that the current will pass from *a* to *b* through the switch blade *S*. If the blade is raised in the direction of arrow *C* the circuit will be opened. When the switch is closed it is necessary that the blade rest firmly upon the stud *b*, and to render this certain a spring washer is provided at *e*, Fig. 71, and *S* is set so that it must spring up slightly to pass over *b*.

Another modification of the simple side throw switch is shown in Figs. 72 and 73, these being top and side views, respectively. The difference between this and the former design is that the swiveling point is transferred from the end to the center of the switch blade. With this construction it would be easy for the blade to be raised from *b* by a downward pressure of the hand of the operator, and to avoid any trouble from such an occurrence the spring *f* is provided. This spring serves to hold the blade down, but even if it should be raised, no damage would be done, as *f* and *b* are electrically connected, therefore the current would pass from *S* to *f* and thus to *b*. The spring is provided so as to keep *f* in place. As the frequent movement of *S* around *a* would tend to loosen the nuts *e*, these are made double—that is, a nut and a check nut are used—and, except for small switches, a spring washed as *e* in Fig. 71 is also provided. The switch shown in these two figures is made so as to swing in both directions, but it can also be made to have but a single direction of motion.

In Fig. 74 is shown a switch that can be used for two purposes, one to connect one terminal of a line with

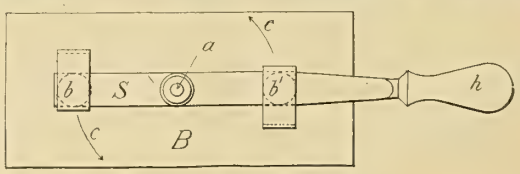


FIG. 74.

two wires, and the other to open or close the circuit at two points at the same time. If the center stud *a* is connected with one terminal of the line, and *b b'* are connected with separate wires, then it can be readily seen that when the switch blade is moved to the closed position as shown in the figure, the current entering through the wire connected with *a* will divide and pass out through the two wires connected with *b* and *b'*. If one end of the line wire is connected with *b* and the other with *b'*, then if the switch blade is moved in the direction of arrows *C* there will be a break in the circuit between *S* and *b'* and another one between *S* and *b*, hence two points in the circuit will be opened at the same time.

The switch shown in Fig. 75 can be used to connect one wire with four, or it can be used to produce four

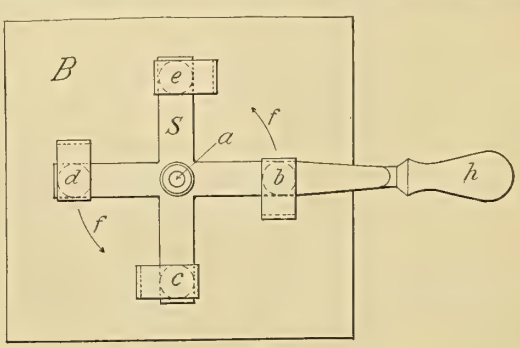


FIG. 75.

breaks in the same circuit, but to accomplish this last result it would have to be slightly modified in so far as the blade construction is concerned, as will be shown hereafter. If one wire is connected with the

center stud *a*, four wires can be fed from the four studs *b c d e*, and all can be connected or disconnected at the same time by the movement of a single handle *h*.

Side throw switches are used almost exclusively for small currents, as, for example, for connecting the voltmeters with the circuit. For large currents the knife blade type of switch is the one universally adopted.

Switches are designated not only according to their form, but also according to the operations they perform; thus we have single and double pole switches, single and double break switches, single and double throw switches, etc. Nearly all these types of switches are made, as a rule, of knife blade design, although the side swing type is also used to a limited extent. Diagrams that represent the latter design, are, however, more simple, and show more clearly the operations performed by the different types, therefore we will use them in the following explanations.

Diagram Fig. 76 represents what is called a single-throw single-break switch. It is called a single-throw

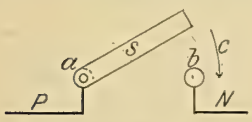


FIG. 76.

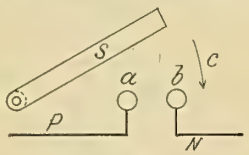


FIG. 77.

switch because the movement of *S* can only open or close a single circuit—that is, the terminals *a* and *b* of the line wires *P* and *N* can be connected when *S* is moved down in the direction of arrow *C*. If *S* is arranged to move in either direction, as in Fig. 72, the switch will still be single throw. The switch is designated as single-break because when it is opened it only breaks the circuit at one point, between *b* and *S*.

Diagram Fig. 77 represents a single-throw double-break switch, and it will be noticed that the difference between it and Fig. 76 is that *S* is not pivoted at *a*, hence when it is in the open position *S* is entirely disconnected from the circuit. When *S* is lowered it connects *a* with *b*, and when it is raised from this position two breaks are made in the circuit, one between *S* and *a* and one between *S* and *b*.

Diagram Fig. 78 is a single-throw quadruple-break switch. When *S* is moved in the direction of arrow *e*

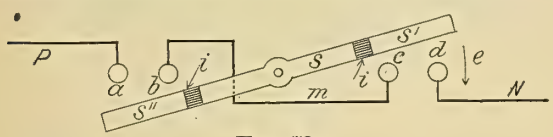


FIG. 78.

the ends *S'* and *S''*, which are insulated from *S* and from each other, connect wires *P* and *N* by closing the circuit between *a* and *b* and also between *c* and *d*. When *S* is moved upward the circuit is opened at four points, between *a* and *S''*, *S''* and *b*, *c* and *S'*, *S'* and *d*. It can be seen at once that if the switch lever *S* is made with more insulated sections, such as *S'* and *S'''*, and each one of these connects two points, then the number of breaks can be increased; hence, a switch can be constructed with any number of breaks, therefore we can divide them into single and multiple break switches. In practice more than four breaks are seldom used. The object of introducing a number of breaks is to reduce the size of the spark produced when the switch is opened. If two breaks are used, there will be two sparks, but each one will be less than one-half the size of the single spark obtained with a single break. With four breaks there will be four sparks, but each one will be much less than one-fourth the size of the single spark. Switches with multiple breaks are used only with currents of high voltage, or high voltage and strength combined. For a very strong current with low voltage the single break acts well enough, as the spark produced when the switch is opened is short, the length of the spark being dependent upon the voltage.

Diagram Fig. 79 shows a double-throw single-break switch, and diagram Fig. 80 is a double-throw double-break switch. In these two figures it will be seen that

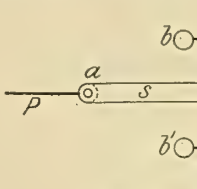


FIG. 79.

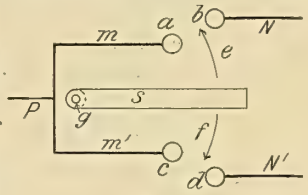


FIG. 80.

if *S* is moved in the direction of arrow *e*, wire *P* will be connected with wire *N;* and if it is moved in the direction of arrow *F*, *P* will be connected with *N';* hence there are two directions in which the switch can be moved to close the circuit.

Diagram Fig. 81 shows a multi-throw single-break switch, and diagram Fig. 82 is a multi-throw double-break switch. In the first figure the wire *P* can be

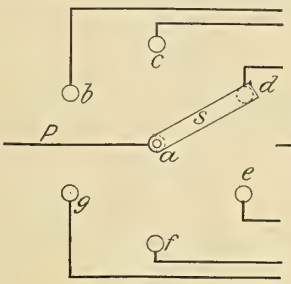


FIG. 81.

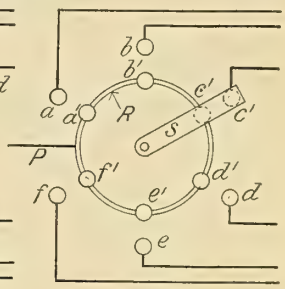


FIG. 82.

connected with any one of the six wires leading off from the contacts *b c d e f g* by the movement of *S*, but in each case the circuit is only opened at one point. In Fig. 82, however, wire *P* connects with all the contacts of the inner circle, these being joined by the ring *R*, and *S* is not directly connected with *P*, hence when it is moved so as to connect any two contacts it closes the circuit at two points, just as in the case of Fig. 77.

The switches so far explained are of the single pole type—that is, they open or close the circuit at one place only. The wire *P* in these diagrams may be considered as one of the leads coming from the generator. In Figs. 83 to 86 switches of the two pole type are

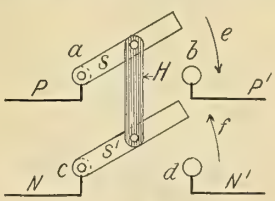


FIG. 83.

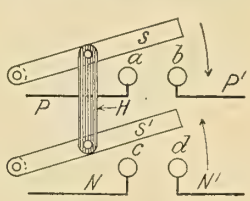


FIG. 84.

shown. In Fig. 83 the switch *S* connects *P* with *P'*, and switch *S'* connects *N* with *N'*. In Fig. 84 the two switches make the same connections, but the circuits are broken at two points, hence this switch is a two pole double-break single-throw switch, while Fig. 83 is a two pole single-break single-throw switch.

Diagrams Figs. 85 and 86 represent two pole double-throw switches, the first being single-break and the second double-break. In both cases movement in the

direction of arrow e connects wire P with P' and N with N', while movement in the direction of arrow f connects P with P'' and N with N''. Fig. 85 is a single-

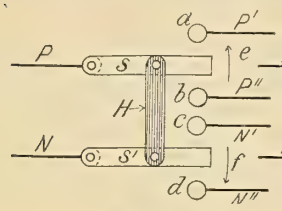


FIG. 85.

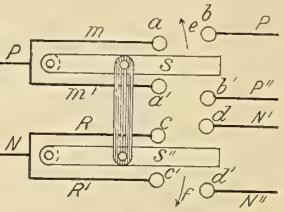


FIG. 86.

break and Fig. 86 is a double-break switch. The link H is a connection made of insulating material, and is provided so that the two switches may be moved together.

It can be readily seen that a switch can be made that will open or close the circuit in three or more wires just as well as in two, and also that the multi-throw arrangement of Fig. 81 can be applied to such switches. It can also be seen that the multi-break construction of Fig. 78 can be applied to any number of poles or any number of throws, hence we can have multipole, multi-throw, multi-break switches.

A single pole switch is one that opens or closes a single circuit. A multi-pole switch opens or closes more than one circuit. A single-throw switch can only connect one terminal with another terminal. A multi-throw switch can connect a single terminal with more than one opposite terminal. A single-break switch opens or closes the circuit at one point only. A multi-break switch opens and closes the circuit at more than one point.

Figs. 87 and 88 show two different types of reversing switches. In the first figure, if the movement is in

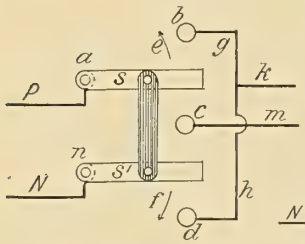


FIG. 87.

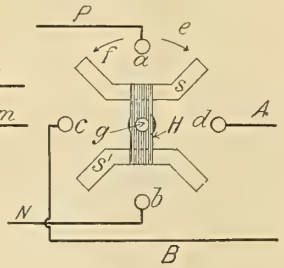


FIG. 88.

the direction of arrow e, S connects P with k, through wire g, and S' connects N with m. If the movement is in the direction of arrow f, S connects P with m, and S' connects N with k, through wire h. In Fig. 88, if the movement is in the direction of arrow e, S connects contacts a and d, while S' connects b and c, thus connecting wire P with A and wire N with B. If the movement is in the direction of arrow f, S connects a with c and S' connects b with d, thus connecting P

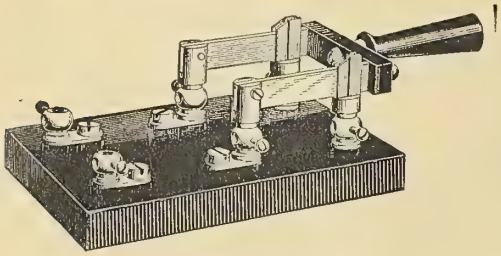


FIG. 89.

with B and N with A. The connection H is made of insulating material just as in Figs. 83 to 87.

Figs. 89 to 93 show actual forms of switches for currents of large capacity, this design being what is called the knife blade type. Fig. 89 is a double pole

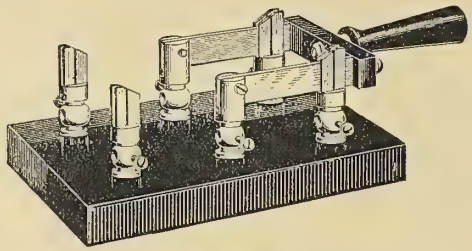


FIG. 90.

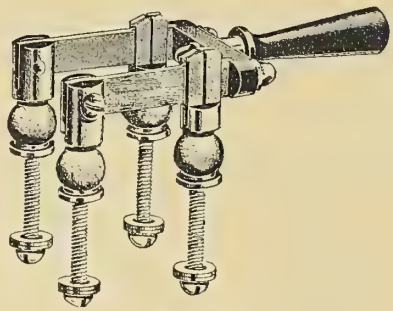


FIG. 91.

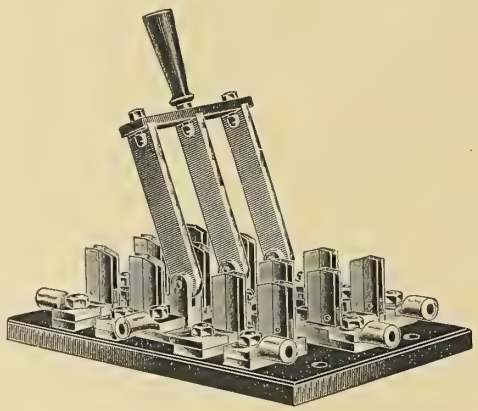


FIG. 92.

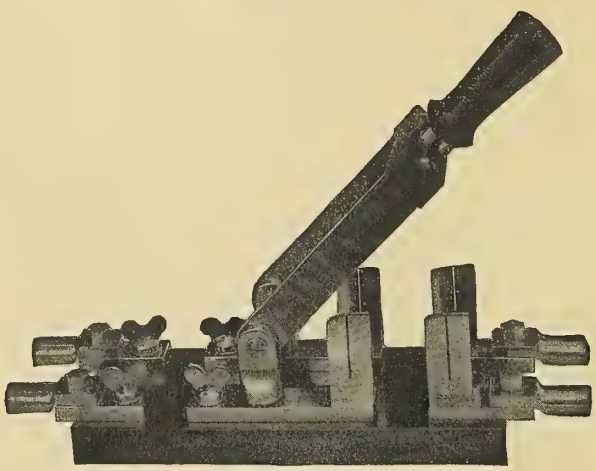


FIG. 93.

single-throw and single-break switch. Fig. 90 is a double pole double-throw single-break switch. Fig. 91

shows the parts of Fig. 89 removed from the base. The switches are furnished with a base for ordinary use, but for switch board purposes the parts are located directly upon the switch board face.

Fig. 92 illustrates a three pole double-throw double-break switch, and Fig. 93 is a two pole single-throw double-break switch. In all these designs the knife blades are insulated from each other, the handle and the cross bar being made of an insulating material.

The Navy Departments of the European powers are greatly exercised over the reported successful trials of the French submarine torpedo boat Gustave Zédé. A trial was recently carried out in which the boat made an attack on the French warship Magenta. During the trial the boat sank below the waves so rapidly that the gunners would in action have been unable to have struck her with projectiles, and she succeeded in landing her torpedo in a vulnerable place. After discharging the torpedo the boat appeared at a considerable distance off, in a direction different from that in which it was last seen before submersion. A larger boat is now being built which will be equipped with more powerful propelling machinery, and further and extensive trials will be made. The Gustave Zédé is operated by storage batteries, but the new boat will have steam engines as well.

ENGINEERS' DICTIONARY—XV.

Engine.—In the most general sense an *engine* may mean any apparatus used for producing some mechanical effect. In the *steam engine* the mechanical force arising from the elasticity and expansive action of steam is made available as a motive power. The marine steam engine may be classified in various ways according to the special features under consideration. The typical modern marine engine, Fig. 54, may be defined as a *vertical, inverted, direct-acting, multiple expansion, condensing,* engine. We will give briefly the significance of these various terms.

In the early days of marine engineering the engines were often horizontal, as shown in Figs. 55 and 56, and such are still met with occasionally in special types of warship practice and elsewhere. An intermediate type known as the inclined engine has also been used to a considerable extent with paddle wheels. (Fig. 57.)

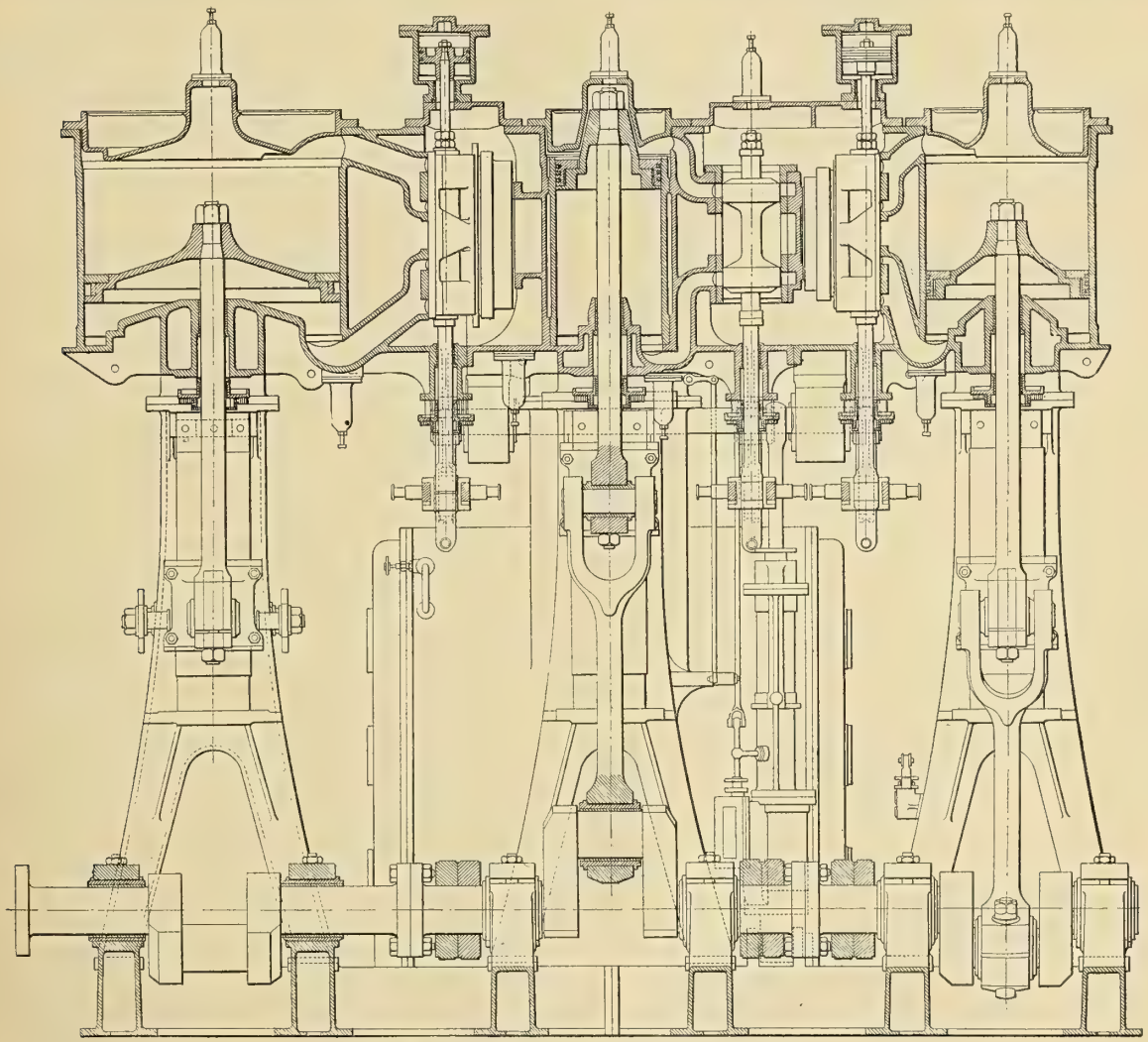


FIG. 54.—MODERN TRIPLE-EXPANSION ENGINE.

In modern practice with rare exceptions the marine screw engine is vertical, as in Fig. 54.

In the earlier vertical marine engines the cylinder was at the bottom and the motion of the parts proceeded upward either directly to the crank shaft as in the oscillating engine, Fig. 58, or to a beam or intermediate mechanism, whence it came back to the shaft. See Fig. 59. In the modern engine the cylinders are on

top and the motion of the parts proceeds downward to the shaft. Hence in comparison with the earlier type the modern engine is called *inverted.*

Where the conecting-rod and crank lie beyond the crosshead or farther end of the piston rod, as in Fig. 54,

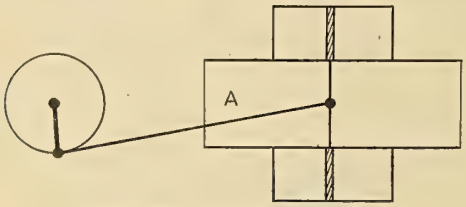


FIG. 55.—TRUNK ENGINE.

the engine is said to be *direct-acting.* In certain early types of horizontal engines in single-screw ships, as represented in Fig. 60, the cylinder was sometimes placed close to the shaft and two piston rods were fitted passing over beyond the shaft, one above and the other below. Then from a crosshead at this point the motion came back to the crank pin by a connecting-rod in the usual way. Such engines were called *return*

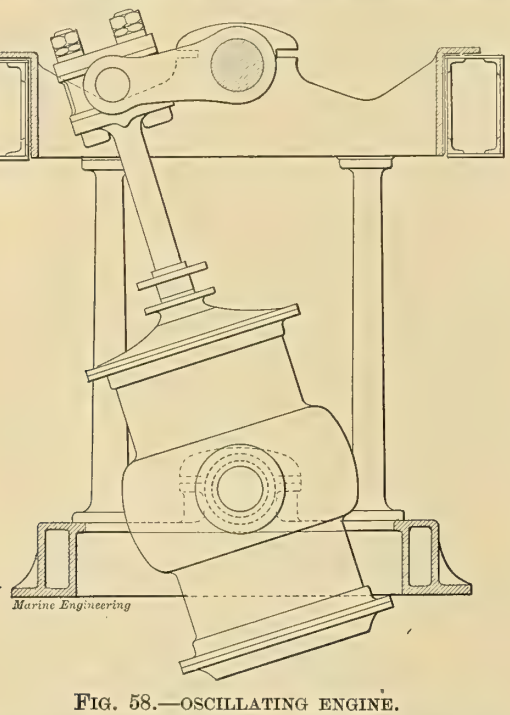


FIG. 58.—OSCILLATING ENGINE.

connecting-rod or *back-acting.* In still earlier times the same type of engine placed on end, with the cylinder at the bottom, and known as the *steeple* engine, was frequently fitted in side-wheel paddle steamers, and a modification of this is occasionally used now abroad.

In early marine engines the expansion of the steam always took place in one cylinder only. Such engines are termed *simple.* In the typical modern engine the steam is passed through a series of cylinders from one

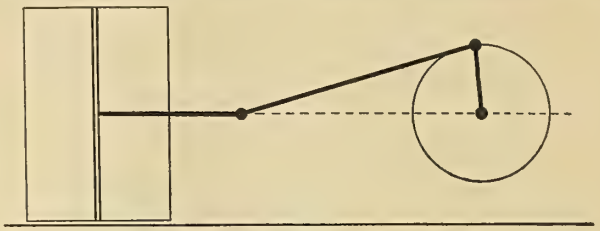


FIG. 56.—HORIZONTAL ENGINE.

to another of increasing size. Such engines in general are termed *multiple expansion.* If the steam is thus used successively in two cylinders or the expansion occurs in two stages, the engine is said to be a *compound;* if in three stages, it is a *triple* or *triple expansion;* if in four stages, it is a *quadruple* or *quadruple expansion,* etc.

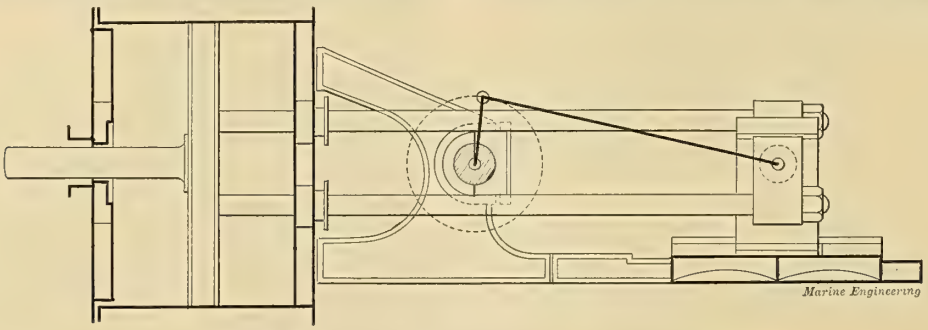


FIG. 60.—RETURN CONNECTING ROD ENGINE.

Where the steam after being used in the cylinder is exhausted into the air, the engine is said to be *high-pressure* or *non-condensing.* In the typical modern

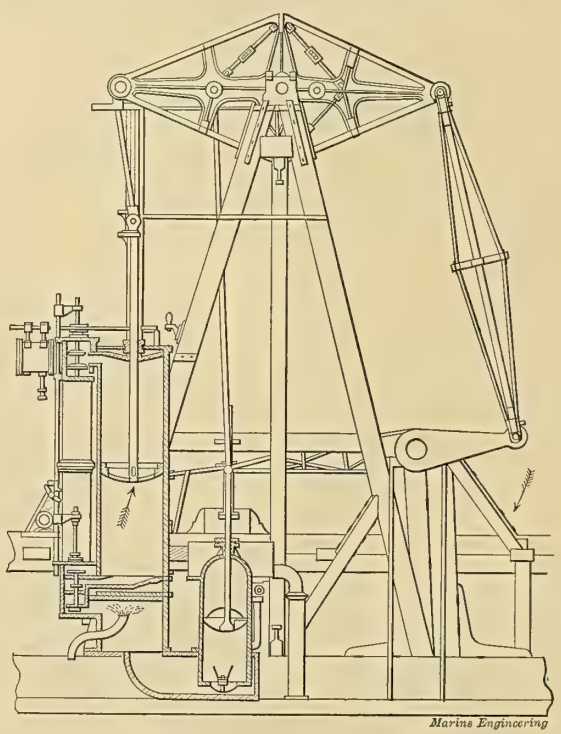


FIG. 59.—BEAM ENGINE.

engine the steam is exhausted to a condenser, thus giving the advantages of an increased ratio of expansion and decreased back pressure. Such engines are called *condensing*.

Engines are often given special names according to the nature of the mechanical movements employed.

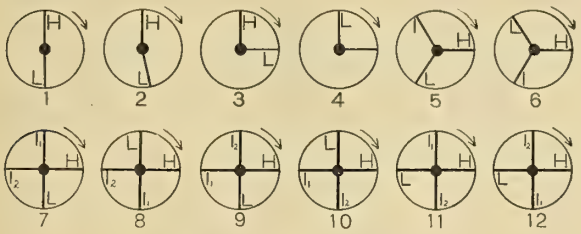


FIG. 62.—CRANK ANGLES.

In the usual type, as already noted, the motion is direct-acting and proceeds through piston, piston-rod, crosshead, connecting-rod, crank pin and crank shaft. In the beam engine, as shown in Fig. 59, the motion passes from the piston-rod to a crosshead and then by

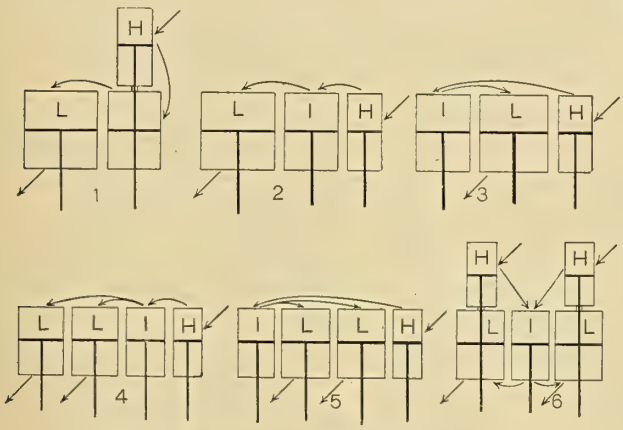


FIG. 63.—TRIPLE ARRANGEMENTS.

link or parallel motion to the beam. Thence from the other end of the beam it passes by the connecting-rod to the crank pin and crank shaft. Such engines are especially suited to side-wheel paddle steamers, and for many years have been considered the standard engine for use on river, bay and lake steamers. In more recent years, however, the vertical direct-acting engine and screw propeller are to a considerable ex-

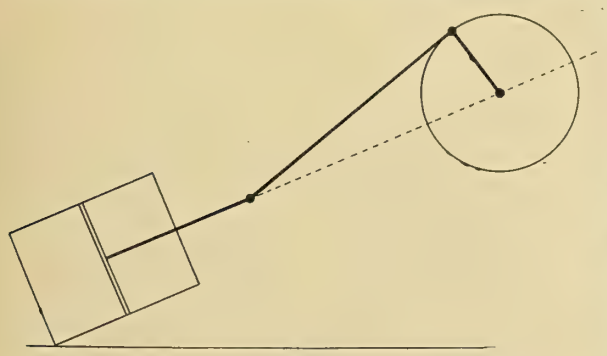


FIG. 57.—INCLINED OR DIAGONAL ENGINE.

tent displacing the beam engine and paddle wheel in its own territory.

In the oscillating engine, a favorite in British practice for side-wheel paddle steamers, the cylinders are located below the shaft and are swung on trunnions, as shown in Fig. 58. The piston-rod is connected directly to the crank pin, the piston-rod and connecting-rod forming thus but one member. This is made possible by the swinging of the cylinder upon its trunnions, as shown by the figure. The *trunk* type of horizontal engine, as shown in outline in Fig. 55, was often fitted in former years where economy of transverse or athwartship dimension was necessary. In

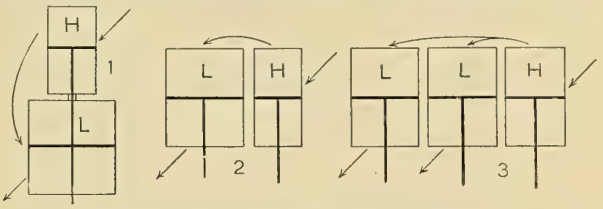


FIG. 61.—COMPOUND ARRANGEMENTS.

this engine the use of the piston-rod was avoided by the large trunk *A*, to which the connecting-rod was directly attached, as shown.

The stern-wheel western river boat engine is a direct-acting horizontal engine connected to the stern wheel, and provided with a peculiar type of valve gear. For full description see MARINE ENGINEERING, November, 1897.

In speaking of the principal parts of the modern

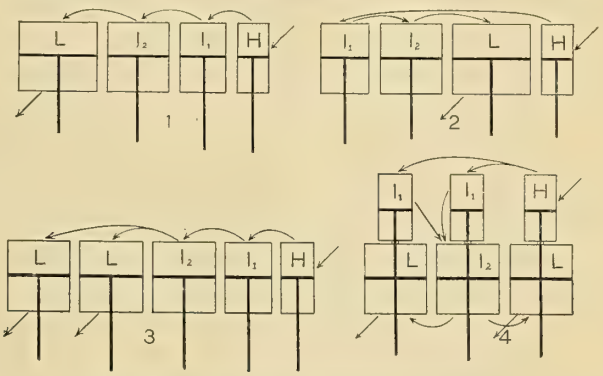


FIG. 64.—QUADRUPLE ARRANGEMENTS.

typical engine, we may note first the stationary and then the moving parts. The *cylinders* are at the top and consist each of a cylindrical chamber containing the moving piston which is forced by the steam alternately in one direction and then in the other. Attached to and part of the cylinder casting are the valve chests and connecting ports and passages. Within the valve chests are the valves, either flat or cylindrical themselves, which regulate the entrance and exhaust of steam at each end of the cylinder alternately. See also under the heading *Cylinder*. The cylinders rest on the columns, which are either of the inverted Y or of the cylindrical type, as described under the heading *Column*. The columns rest on the *bed-plate* (see under that heading), and this in turn rests on the *engine seating*, a part of the structure of the ship specially strengthened to carry the weight and extra stress which must be taken care of at this point.

Of the moving parts the *piston* is acted on by the steam and is forced alternately to and fro in the cylinder. The piston is carried by the piston-rod, at the lower end of which is the crosshead. Here by a pin joint connection the connecting-rod is attached. (See also under *Crosshead* and *Connecting-rod*.) At the lower end the connecting-rod contains the *crank pin*, and thus connection is made between the piston and the crank shaft, and the to-and-fro motion of the former is transformed into the rotary motion of the latter. From the crank shaft the rotary motion is transmitted directly through the line shaft to the propeller. The valves moving within the valve chests

are driven by the *eccentrics* (see under that head) through one of the various forms of valve gear employed for marine engines.

Cylinders are usually made of cast iron; frames and columns of cast iron, cast steel or forged steel; bed plates of cast iron or cast steel; pistons of cast steel; piston-rods, connecting-rods and crank shafts of forged steel; crossheads of cast iron, cast steel or forged steel; valves of cast iron, and most other parts of the valve gear of forged steel.

The various members of a multiple-expansion marine engine may be arranged in a great variety of ways as regards the location of the cylinders, the crank angles, and the way in which the cranks follow each other around in the revolution. These are illustrated on the preceding page. Of the many combinations which might be made, only the more important are mentioned. Throughout these diagrams the high-pressure cylinder is denoted by *H*, the low-pressure cylinder by *L*, the intermediate cylinder of a triple-expansion engine by *I*, and the first and second intermediates of a quadruple-expansion by I_1 and I_2, respectively. Where the total cylinder volume is divided between two, each of half size, both of the latter are given the same letter. The course of the steam through the engine is also indicated by the arrows. For compound engines the usual arrangements are illustrated in Fig. 61. We may have two or three cylinders and one, two or three cranks. In the latter case the entire volume of low-pressure cylinder is divided between two cylinders, each of half the total volume. The first arrangement with high-pressure cylinder on top of low-pressure is known as a single-crank *tandem* compound, but is rarely met with in marine practice. The other arrangements may be placed, of course, with either end forward. The various crank angles are shown in Fig. 62 at 1, 2, 3, 4 and 5, the crank marked *I* in No. 5 being in this case for one of the L. P. cylinders. With two cranks the angle between may be either 90 deg. or 180 deg., or slightly greater or less than 180 deg., as 175 deg. or 185 deg. The 90 deg. angle is undoubtedly the best for all-around service. The 180 deg. angle gives a better balance to the moving parts and admits of a simplification of valve gear, and is sometimes preferred for these reasons. There is, however, a liability of the engine's sticking on the center and the general readiness of handling is less than with cranks at 90 deg. To overcome this, angles of 175 deg. or 185 deg., as shown at 2, are sometimes used, the balance of moving parts in such case being substantially as good as with an angle of 180 deg.

With three cranks the angles are usually equal, and hence 120 deg. each. Occasionally they are slightly varied from these valves in order to give a more uniform rotative effort, or to give a better balance to the forces causing vibration.

For the triple-expansion engine the more important arrangements of cylinders are shown in Fig. 63. We may have three cylinders or more, and two, three or more cranks. The most common types have either three or four cranks, in the latter case the total L. P. volume being divided between two cylinders, each of half the total volume. The crank angles are usually 120 deg. with three cranks, and 90 deg. with four, though occasionally slight variations from these valves are adopted in order to obtain a better balance of the forces causing vibration. Of the various arrangements of cylinders shown in Fig. 63, each may, of course, be placed either end forward in the ship. We may also have the various sequences and arrangements of cranks as indicated in Fig. 62, the changes of lettering where necessary being readily seen.

For the quadruple-expansion engine the more important cylinder arrangements are shown in Fig. 64. The number of cylinders may be four, five or six, with four or five cranks. With five cranks the angles are usually equal, and hence of 72 deg., though as with three and four cranks slight departures might be made to obtain a better balance of the forces producing vibration. The arrangements of cylinders shown in Fig. 64 may be placed in the ship either end forward, and various crank sequences in addition to those shown in Fig. 62 may be easily arranged. One of the chief tendencies of modern practice is to pay especial attention to the balancing of the forces producing vibration. The use of irregular crank angles in this connection has been already referred to. In addition, and of not less importance, the larger cylinders with the larger and heavier pistons are now frequently placed inside, with the lighter moving parts on the outside, as in Fig. 63, Nos. 3 and 5, or Fig. 64, No. 2.

Eduction Valve or Pipe.—The same as a discharge valve or pipe. The word *eduction* means *leading from*

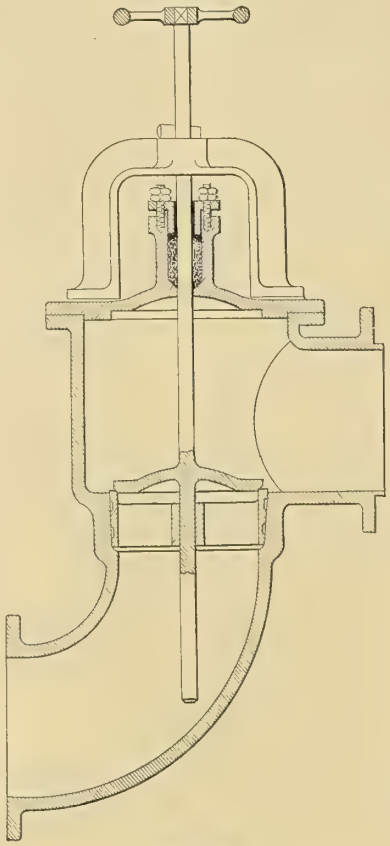


FIG. 65.

or away. Fig. 65 shows a side discharge valve for a steamship.

1899 Meeting of S. N. A. and M. E.

The following notice has been sent out by the Society of Naval Architects and Marine Engineers:

"The executive committee invites correspondence as to papers to be read at the seventh annual meeting in November next. It is necessary for intelligent discussion that papers should be in print thirty days before the meeting, and, therefore, members who desire to submit papers or who have suggestions to make are requested to communicate with the secretary at their earliest convenience.

"The following resolution was unanimously adopted at the sixth annual meeting:

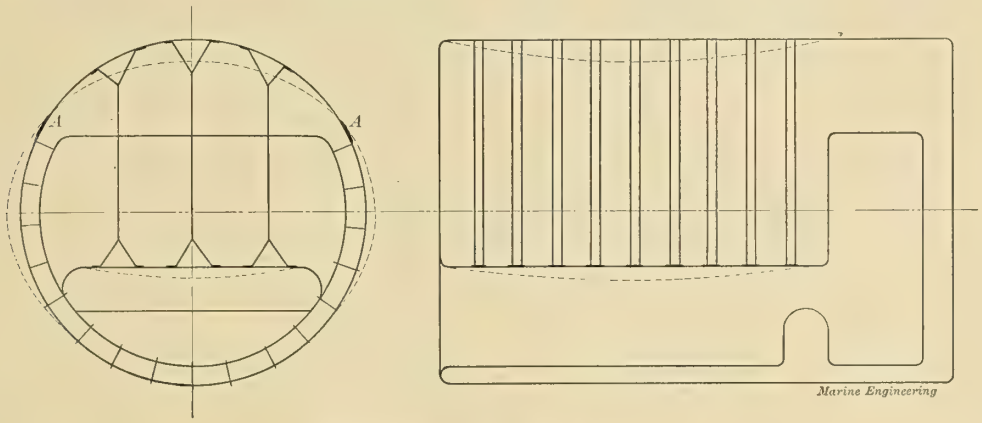
" 'That papers be invited upon the subject of life-saving at sea for the next annual meeting, and that two such papers be selected by the executive committee for publication and discussion.'

"Members are invited to suggest names of persons outside the society who might be asked to prepare papers on this subject."

QUERIES AND ANSWERS.

Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—I send a sketch of a boiler which collapsed at 160 lb. pressure, as shown in the dotted lines, while undergoing the hydrostatic test. The boiler was built of 60,000 lb. T. S. steel, and was 6 ft. 6 in. dia. and 11 ft. long. The circular seams were single riveted and the longitudinal seams double riveted. The bracing between the shell and crown sheet was "crow foot," and no angle scantling was used in the construction. As shown in the sketch the crown sheet came down 1 in., the top of the boiler 2 in., and each side bulged out 1 in. The rivets broke in the longitudinal seams. The boiler was built exactly in accordance with the U. S. inspection rules for 135 lb. steam pressure. I would like to know if it was properly braced. U. S.



DIAGRAMS OF COLLAPSED BOILER.

A.—The distortion of the boiler as described in your letter and shown in the sketch is just what might be expected from the circumstances of the case, and if the boiler was built and braced according to U. S. rules it proves either that the rules are not correct for such a form of boiler, or that they were never intended to apply to such a type of construction.

To explain how the forces would act let us consider first a cylindrical shell subject to pressure. The shell is in complete equilibrium, there is no tendency to change form, and the stress in the metal is wholly along a tangent line. In particular note that there is no tendency of the plate at any point to move outward away from the center. Suppose now a brace put in right across from side to side along a diameter. Such a brace, it is clear, will do no good whatever. The plate does not tend to move in the direction of the brace, there is no stress upon it, and it is entirely without influence for either good or bad.

Now consider the condition of a brace tying together two flat plates, as, for example, the two heads of a boiler. Such a flat plate is not in equilibrium under pressure. Each head tends to bulge outward, and this tendency gives rise to a load on the brace, coming, so to speak, from each end of the boiler. That is, the head on the right, let us say, tends to bulge outward and thus to stretch the brace, and thus throws it into a condition of tensile stress. Similarly the head on the left tends to bulge outward and thus tends to stretch the brace to the left, and so puts a load on it also in tension. These two tendencies balance each other, thus putting the brace into tension and leaving the heads to depend on its strength for their support. If of sufficient strength for the load, the brace holds and the plates are supported.

Now turn to the braces tying the flat crown sheet to the shell of the boiler. Note that the tops of these braces are attached to the cylindrical shell, and that so long as it retains this form there is no load whatever put on the braces by the shell itself. On the lower end the case is different. The plate is flat and tends to bulge downward. This puts a load on the braces and puts them into tension. Now note that to resist this tendency of the braces to come down there is available no pull upward coming from the pressure on the shell. There is available nothing but the strength of the cylindrical shell as an arch. If it is stiff and strong enough as an arch to carry the load without yielding, well and good. This is frequently the case where the flat top of a combustion chamber or of a furnace or fire-box is safely supported in this manner. If not, then it yields and comes down, naturally carrying the sides outward, as shown in the figure. This will continue until the curvature of the shell at the upper end of the braces and that of the furnace crown sheet at the lower end are such as to bring their loads into some kind of equilibrium. That is, after the distortion the shell is no longer cylindrical, and the pressure will of itself tend to force the upper part of the shell back to its original position. This puts a tension upon the braces. Similarly on the crown sheet the curvature is quite gentle and simply relieves slightly the downward load on the braces, leaving still a pronounced tension downward to balance the tension upward coming from the shell. Thus the shell and crown sheet have brought themselves into equilibrium, and aside from the breaking of the rivets at the seams, the boiler might have lived to a good old age and have done good service without further trouble. In any event, as a structure it was in a far more stable and satisfactory condition after the distortion than before, so far as its equilibrium under the internal forces is concerned. The moral of this experiment seems to be: Don't build boilers in this way, or if you do, run circumferential Tee or angle irons around the upper part of the shell. This will strengthen it as an arch, and enable it to support the load coming from the crown sheet.

Q.—Will you kindly explain at length the examples in the educational series on page 47 of the December, 1898, issue, as follows:

$$3\ [16 - 2\ (3 + 4 - 2)] = 18$$
$$3\ [16 - 2\ (3 + 4) - 2 + 4\ (3 - 1)] = 24$$
$$3\ [16 - 2\ (3 + 4 - 2) + 4\ (3 - 1)] = 26$$

I cannot work out any of these to read correctly. The use of [( )] puzzles me completely. STUDENT.

A.—The key to all operations with brackets is to remember that everything within any one pair of brackets is to be considered as a single quantity, and each term within the bracket must be treated in exactly the same manner. The principles are stated and explained in § 8 of the "Calculations for Marine Engineers," to which you refer. You will perhaps understand the examples better by taking the operations more in detail as follows:

The first in § 8 is $2\ (3 + 4 - 2) = 10$. Here we first combine the quantities inside the () and find $3 + 4 - 2 = 5$. This result we then multiply by 2, which gives $2 \times 5 = 10$, the answer.

To reduce the more complicated expressions, such as those which you quote above, a very good way for the beginner is to write the example over again several times, taking off one set of brackets at a time, and thus gradually reducing it to its

final value. Thus taking the first one above, we may write it four times over, thus:

$$3\ [16 - 2\ (3 + 4 - 2)]$$
$$3\ [16 - 2 \times 5]$$
$$3\ [16 - 10]$$
$$\text{or, } 3 \times 6 = 18.$$

Taking the next example, we may reduce it as follows:

$$3\ [16 - 2\ (3 + 4) - 2 + 4\ (3 - 1)]$$
$$3\ [16 - 2 \times 7 - 2 + 4 \times 2]$$
$$3\ [16 - 14 - 2 + 8]$$
$$3\ [24 - 16]$$
$$3 \times 8 = 24$$

In the last example which you quote there was, by oversight, an error in the location of the last]. It should not include the expression 4 (3 — 1). The example should then read

$$3\ [16 - 2\ (3 + 4 - 2)] + 4\ (3 - 1),$$

and we reduce it thus:

$$3\ [16 - 2 \times 5] + 4 \times 2$$
$$3\ [16 - 10] + 8$$
$$3 \times 6 + 8$$
$$18 + 8 = 26$$

By working in this way you will probably have no further trouble with examples of this nature.

Q.—In the February issue, under the head of "Mechanics," in the educational series, there is a rule for finding the H. P. of an engine from the foot pounds work it does. I don't know how to find the foot pounds work of an engine. Will you please give me some rule to find them, for both stationary and marine engines? J. A. B.

A.—The rule you refer to was not intended especially for finding the horse power of an engine, but rather to illustrate the difference between *power* and *work*. The measure of the work in foot pounds per minute for an engine is, however, readily found as follows: By the definiton of work in the paragraph preceding the one to which you refer, the foot pounds for the steam engine will be the product of the acting force multiplied by the distance through which it acts in one minute. The acting force equals the mean load on the piston, and this equals the mean effective pressure per square inch multiplied by the area in inches. The distance moved per minute equals twice the stroke in feet multiplied by the revolutions per minute.

Let p = mean effective pressure in pounds per square inch; A = area of piston in square inches; L = length of stroke in feet; N = revolutions per minute. Then $p\ A$ = acting force or mean total load on piston, and $2\ L\ N$ = distance moved per minute = piston speed.

Hence foot pounds of work per minute equals the product $(p\ A) \times (2\ L\ N)$, or what is the same thing, $2\ p\ L\ A\ N$. Hence

$$H.\ P. = \frac{2\ p\ L\ A\ N}{33{,}000}.$$

This is the usual formula for finding the indicated horse power, and is referred to in § 8 of the "Calculations for Marine Engineers," published in the January number of MARINE ENGINEERING, page 34.

The mean effective pressure p must, of course, be found by means of an indicator card. The details of this operation would, however, take us beyond the limits of the present answer.

For illustration suppose:

p = 32 lb.
L = 3 ft.
A = 2,000 sq. in.
N = 100.

Then mean piston load = 32 × 2,000 = 64,000 lb. Distance traveled per minute = 2 × 3 × 100 = 600 ft. Foot pounds per minute = 600 × 64,000 = 38,400,000. We should find the same result, of course, by multiplying together the five factors, 2 × 32 × 3 × 2,000 × 100. Hence,

$$I.\ H.\ P. = \frac{38{,}400{,}000}{33{,}000} = 1{,}164.$$

Q.—The following is a description of a steam yacht and its engine which I use in New England waters during the summer months. I want to get all available speed out of her, and think a change in the size or shape of the propeller would be to that end.

The yacht is 52 ft. long over all; about 45 ft. water line, and 42 ft. keel; beam on deck 9 1-2 ft., and about 7 1-2 ft. at water line. From this you see there is but little bilge. I carry about one ton of lead on her keel to make her steady, and it answers the purpose first rate. She is very sharp at the bow. The engine is a compound; the H. P. cylinder is 5 1-2 by 9 in., the L. P. 9 in. by 9 in. The boiler is 52 in. high, 42 in. dia. Am allowed to carry 200 lb. pressure. Generally run her at about 160 lb., with 230 revolutions to the minute. Think the engine makes about 1,000 revolutions to the statute mile, but am not certain of this point. The present propeller is 42 in. dia., with about 5 ft. pitch, has four blades and is made of iron. There is room for a 44 in. wheel.

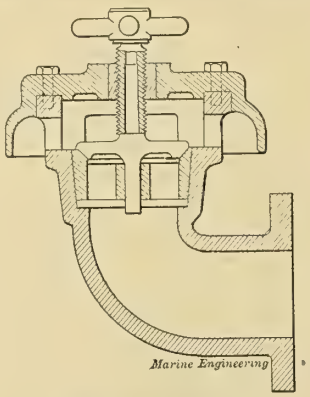
What material would you advise to make the wheel of? Think the galvanization induced by the bronze while under the water rots the iron and makes a blade liable to be broken off in case of striking a log or any partly submerged debris. J. C.

A.—The information given in your statement is not sufficiently complete to make possible a satisfactory determination of the wheel best suited to your purposes. In connection with the boat the draught is not given, and only a rough estimate at best can be made of the displacement. In connection with the engine it is not stated whether it is condensing or non-condensing, and without indicator cards only a rough estimate, at best, can be made of the power developed. If your present wheel is of 5 ft. pitch, then with a probable apparent slip of 15 per cent to 20 per cent the revolutions per mile would be some 1,200 to 1,300 rather than 1,000, or if the latter figure is correct, then the pitch is probably some 6 ft. or more rather than 5 ft. From a general estimate of the conditions, it seems likely that you would do rather better with a wheel of smaller diameter, smaller pitch ratio, and higher revolutions, say 36 in. dia. and 45 in. pitch, running from 300 to 350 revolutions per minute. If, however, it is desired to keep the revolutions at about the present number, then the dimensions given are probably not far wrong, provided, of course, that the blades are of suitable area, shape and thickness.

For material, manganese bronze is probably the best, and next common brass. With either of these materials the wheel may be made with smoother surfaces, thinner sections and sharper edges than with cast iron, all of which will help in reaching a higher speed.

Q.—Please explain what a "snifting valve" or "snifter" is and for what it is used. H. H. A.

A.—The snifting valve was a valve fitted to the older types of jet condenser. In form it was a disk valve, carried on a spindle, as shown in the figure, opening outward, and provided with a hand wheel and screw for holding it down when desired.



SNIFTING VALVE.

To this extent it was similar to a boiler feed-check, opening outward instead of inward. Means were provided so that when making preparations for getting under way steam was blown directly through into the condenser, thus driving the air out through the snifting valve. When the air was thus expelled and the condenser filled with steam the injection was turned on, thus forming a vacuum. The snifting valve would then automatically close, preventing the return of the air, and for extra precaution could be kept closed by the screw hand wheel if desired.

RECENT PUBLICATIONS.

THE OLD NAVY AND THE NEW. Memoirs of Rear-Admiral Daniel Ammen, U. S. N. (deceased). J. B. Lippincott Co., Philadelphia, Pa. Second edition. Size, 6 by 9. Pages, 553. With frontispiece. Cloth, $3.25.

During and since the war naval matters have held a very prominent place in the attention of Americans. Scores of publications, of one sort or another, descriptive of the Navy have been issued and found widespread sale. In most instances, however, these have described the Navy as it is, and a knowledge of the present has induced in the minds of readers a desire to know of the past. For such, much of interest is to be found in the memoirs of the late Rear-Admiral Daniel Ammen, U. S. N., now issued in a second edition under the title of "The Old Navy and the New." The book is many-sided, possessing the interest of personal narrative of a traveler; the historical value of a link connecting the days of sail power with the era of forced draft and 20-knot ships; an insight into social life in the Navy; and so on, giving special information for the specialist and a pleasing combination and variety for the general reader. Admiral Ammen had to his credit a record of more than half a century ashore and afloat. His birthplace was in Brown county, Ohio, and here he first made the acquaintance of a boy whom he one day saved from drowning, and who years afterward was known to the world as President U. S. Grant. It is curious to read of the author's trip to Washington after his appointment in the year 1836, in a stage coach, wrapped up in a Mackinaw blanket, in the company of a lot of Congressmen, trying to keep warm in similar style with the aid of generous draughts of whiskey at the roadside taverns. To-day a Pullman car at forty miles an hour, and dinner on the way, would be the usual way of travel. In the course of his service Admiral Ammen saw a good deal of this earth, both the dry land and the deep waters, and as he was observant and possessed of a sense of humor he, in the course of fifty years, got lots of material for a 500-page book. He also seems to have had a mechanical bent which, in later years, found expression in the armored ram Katahdin. Early in his career, when in a vessel which touched at the island of Java, he noted the primitive method of pile driving. The weight was suspended by a single rope, which at the free end was spliced to twenty separate ropes, each of which was held by a Malay. By alternately hauling and letting go they obtained a fall of about three feet for the weight. An incident which the author narrates at some length recalls the recent osculatory performances of Naval Constructor Hobson. When the U. S. S. St. Lawrence was lying of Southampton, Lieutenant "B," with some brother officers, attended a town ball, and the author says:

" 'B' was always jovial, and being in a window recess with one of the ladies, took the liberty of kissing her. He said that she would not have objected at all had not the curtain allowed the act to be seen by the company." The matter was reported to the captain, and the lieutenant was tried by court martial. He pleaded guilty, but in his defense referred to an order issued during the reign of George II, to the effect that "His Majesty's sea officers are strictly enjoined to be polite to the ladies." Though this order was not mandatory on other than British officers it was the lieutenant's desire to carry out the order on British soil. "As the woman was 'full grown, and had not suffered bodily injury, 'B' was admonished."

The difficulties of navigation in vessels with both steam and sail power are referred to in the narrative of an experience in the Pacific. "I was surprised to see how helpless side-wheel steamers were when under sail alone. The wheels were lashed, the upper paddles taken off, and then the wheels turned over so as to get rid of the drag of the paddles." In these days of long, continuous fast steaming such a proceeding would certainly be novel. The Admiral seems rather to have mistrusted the skill of engineers in general, and he cites a few instances in the book which show that probably his opinions were not formed without cause. He was ordered to join the U. S. S. Waterwitch on a survey expedition to the South American coast. This vessel was of 378 tons and was fitted with feathering paddle wheels "very much too heavy for her." Of his experiences he writes:

"A voyage of five days brought us to Maranham. A considerable indentation in the coast after reaching the wide mouth of the river Amazon enabled us to escape the current until we were near our port, and also the force of the trade winds. The shoal grounds near the outer limits of the Amazon are ooze, so soft that a lead in sounding sinks several feet in it; in consequence we found ourselves held back, the revolutions of the paddles being greatly retarded by the ooze through which the body of the vessel was passing in part. On heading more to seaward we soon got into deeper water, and our paddles made their usual number of revolutions. The engineer in charge was a mere youth, and inert withal. The great weight of the wheels perhaps caused the shaft-bearings on the vessel's side to settle. We should have attempted to line them at Georgetown had it not been for the prevalence of the fever; the operation was on that account deferred until we should reach Maranham. It was intended that this should be done while we were engaged in coaling. As a result of laziness and ignorance, we had not made our inefficient preparations when we had finished coaling. It was supposed that a little pair of jack-screws with a plank between them as a bearing under the shaft, placed on the deck just as near the ship's side as possible, aided by a little screw placed on the end of a rod on the outer part of the wheel, and secured to the masthead, would suffice. From the lack of leverage the idea was ridiculous; and after wasting several days, and having a man knocked overboard from the wheel house by something giving way, his arm being broken at the same time, I suggested to the engineer a simple and obviously effective means of raisng the shafts; although he assented, he was still unwilling to ask the captain to adopt the means proposed. There were a number of lighters of twenty tons' displacement anchored near us; the proposition was by means of cleats to secure stout timbers on the vessel's sides, then lash and wedge these under the wheels after the lighters had been filled with water; when the lighters were baled out they would of course raise the weight of the wheels, which was not one-half of the weight they would float. This was finally done at my suggestion and under my personal superintendence, notwithstanding one of the younger engineers screwed down a pillow block to prevent the shaft from rising. On bailing out the water, as soon as the timbers upon which the wheel was resting began to crack I knew that some rascality was being practised to prevent the operation, and on reaching the deck I saw what it was. We were a fortnight in Maranham, having been detained more than a week through incapacity. At times I have doubted whether the shafts really needed lining; but, at any rate, they were raised half an inch or more at the bearings on the side of the vessel."

With a touch of humor the author relates another "engineering" experience when in command of the U. S. S. Piscataqua. She was put in commission late in 1867 as flagship on the Asiatic station. She was ship rigged and had also a screw propeller, with a disconnecting coupling in the line shafting, with the intention that sail alone would be used in favorable weather. The coupling was placed about 100 ft. from the stern, so that when free the screw had to turn this length of shaft.

"On taking command," says the author, "I had said to the engineer, 'It seems to me that this will be a great retardation.' 'Very little,' replied my scientific friend; 'when the vessel has headway the shaft will turn, and after the revolutions commence it will turn almost without friction.' I found the reverse to be the

case, however, and thought of what the blocks said of the boatswain when they creaked. At a time when there were no friction rollers in blocks, if the latter were not carefully oiled there was great friction, and when they made a noise the sailors would say they were 'damning the boatswain.' So when at sea the vessel made a frightful thumping in turning over 100 feet of the shaft, and I saw that she made only seven knots when otherwise she would have made ten, I could not help thinking that the thumps were damning the engineer who had made it necessary to turn a large part of the shaft that could have been kept quiescent by uncoupling it as far aft as possible."

Civil war experiences fill many interesting pages. Many of his recollections of this time are side lights on now historic events of the war. At the commencement of the war the writer was in Baltimore, and being unable to get northward he secured a horse and rode to Washington, where he offered his services to Commodore Stringham, then in charge of the office of detail. Having no further use for a horse he sold the beast to the patriotic Colonel Ellsworth, who five days afterward was killed at the Marshall House in Alexandria. In 1863 Admiral (then Commander) Ammen formed one of a board to report upon the qualities of the monitors and to make suggestions for their improvement. The board made a number of recommendations and criticisms which referred to lack of ventilation, leakage of water under the turret, disablement of the turret by impact of shot, inadequate armor, and many minor changes in construction and equipment. "In relation to the qualities of the vessels," says the report, "we would remark that they have been exaggerated into vessels capable of keeping the seas and making long voyages alone. . . . When employed against vessels of any class known to us, in smooth harbors, they will hardly fail to be in the highest degree effective, and when their bottoms are clean, would prove powerful rams against vessels of low velocity, or against vessels of greater velocity when embarrassed in intricate or narrow channels." Later in his memoirs he refers to the famous ocean voyage of the monitor Miantonomah with the true comment: "Her voyage furnished an incentive to the European powers to compete in the construction of armored ships, which has continued to the present time, to the end that the last one built should be in point of size, armor plating and battery, more formidable than any that had preceded her." Throughout the book there are frequent references to the author's friendship with General Grant, and in the form of an appendix letters written by General Grant during his trip around the world are preserved. There is a frontispiece of the Admiral, and illustrations of the U. S. S. Katahdin. Other than these there are no illustrations in the volume, but it does not depend for its interest on pictorial display, and then during many of his years of service photography was unknown. The volume is handsomely bound in blue cloth, and is published by the J. B. Lippincott Co., of Philadelphia, Pa.

THE BRITISH NAVY. By A. Stenzel, Captain Imperial German Navy, retired. Translated by A. Sonnenschein. New York, E. P. Dutton & Co. With maps, colored plates and engravings. Size, 7 by 10. Pages, 327. Cloth, $5.00.

For those interested in the subject this is the most satisfactory book that we know of. The author has undertaken his work in a reverent spirit, with a full realization of the grandeur of the subject, and this spirit has been carried out by the translator, who has faithfully followed the original text, changing no statement, but adding only a word by way of commentory here and there, in foot notes. It is a book far above the average of such works, for though written in an easy and good literary style, free from obscure technicalities, it is manifestly the appeal of a graduate in naval affairs to the understanding of a highly intelligent audience. After reading the book one is amazed that any one not a Briton could have gathered together such a multitude of facts about so complicated a subject, and one so intimately connected with that nation's life. In this fact there is the peculiar merit that the work is so impartial and dispassionate, without a trace of exaggeration which a patriotic British writer might be expected to show. The work is divided into these subdivisions: Historic Survey; Admiralty; Naval Policy; Stations, Dock Yards, etc.; Personnel; Education and Training; Uniform; Flags; Service and Discipline on Board; Material, and Conclusion, containing a detailed classification of British vessels. The subject is, of course, tremendously big, and this has demanded nice discrimination, so as to apportion the space at the disposal of the author that each division shall have a proper proportion and relation to the others. He has been very successful in this, by the skilful use of condensation rather than omission, and he has also freed himself from the hypercritical condition of mind which an officer of a continental power might, even unconsciously, assume. In the work of translation Mr. Sonnenschein has availed himself of the professional aid of F. W. Crohn, of Yarrow & Co., Poplar, and of F. Harrison Smith, R. N., so that great accuracy has resulted in the correct rendering of technical terms, especially for those which have no exact equivalents in English. In his preface the translator has called attention to these details and has added as an illustration the distinction, familiar to German readers, between the terms officer (Offizier) and official (Beamte). In view of recent occurrences in the Philippines the significance of these terms is of great present interest to American readers. "Official (Beamte)," says the translator, "denotes the medical officers, paymasters, etc.; in a word, non-combatants, who are not called by the name of officer in German. Indeed, there is an important difference in the German navy between the two classes. The 'officers,' like the crews, take the oath of allegiance to the emperor solely, the 'officials' are sworn to the imperial constitution as well as to the emperor." In the book there are thirty full plate illustrations, twenty-five engravings, and thirty diagrams printed in the text, and four folded maps and plans. Though it is an invaluable book of reference it is no dry recital of regulations and statistics. There are many odd bits of information and comment throughout the book. One of these, for instance, refers to the term "Jack Tar," which is very generally supposed to have originated from the use of tar on the old wooden ships. The author, however, attributes its origin to the use of tarred garments (tarpaulin) by sailors, which "suggested the good-natured nickname 'Jack Tar,' equivalent to 'Blue Jackets.'" Another fact concerning uniforms, which would be a surprise to many, is that the present style of dress of British sailors was adopted only as late as 1857. Previous to that there was great diversity in dress according to the taste of the commander. "As late as 1853 the commanding officer of H. M. S. Harlequin ordered his gig's men to be dressed as harlequins." This book would make a most valuable addition to any marine library, and among its special uses would be that of a handbook of reference for a yachtsman who intended to cruise in foreign—especially British—waters. The colored plates showing distinctions of dress, etc., would for this purpose be a great convenience.

"Centrifugal Pumps, Turbines and Water Motors," by Charles H. Innes, M. A., of Rutherford College, Newcastle-on-Tyne, England, has appeared in a second edition with additions. The subject is very appropriate for a book coming from the author's place of residence, which has long been identified with hydraulic work in its modern engineering forms, for here are the Armstrong works. The book is of convenient desk size for ready reference, and contains over 200 pages, with many drawings and graphic solutions. It is divided into seven parts, which cover:

General principles; pressure engines, producing rotary motion; turbines, where power is obtained by altering the direction of motion and the velocity of the water; steam turbine of the Parsons type; agreement of theory with experiment in water turbines; the centrifugal pump; the fan, and a description of the hydraulic work at Niagara Falls, concluding with a description of the hydraulic buffer stop. The book is scientific rather than descriptive, treating of the mathematics of the subject, and is written especially for the use of engineering students who have the necessary mental equipment to get results out of the book. The book is published by The Technical Publishing Co., Manchester, England, price 3s. 6d., and is for sale here by D. Van Nostrand Co., 23 Murray street, New York.

We are in receipt of the "American Trade Index," more extensively described as a "Descriptive and Classified Membership Directory of the National Association of Manufacturers of the United States," arranged for the convenience of foreign buyers. It is issued from the main office of the association in The Bourse, Philadelphia, Pa. The book consists of 124 pages of text, giving in alphabetical order the names of firms "who make goods suitable for export;" also their addresses and a description of their output and a list of their foreign correspondents. Then follow 134 pages containing a "Classified List of Members," grouped according to the articles which they produce. This book is one of a class of publications which are good enough as far as they go, but unfortunately their contents are influenced by circumstances which prevent their being wholly impartial. In the first lines of the preface the reader is informed that it is the purpose of the "Index" to furnish merchants interested in American goods a *comprehensive* handbook of *the* leading manufactures of the United States, though this statement is modified by inference further along. It would have been wiser to have come out flat-footed and said the purpose of the book was to furnish merchants with a classified membership of the association. For example, under the head of "Shipbuilders" no mention is made of any yard west of Chicago, so that an Oriental reader, who was in the market for ships, might readily believe he could only order from the Atlantic coast. No index which omits the names of the Pacific coast builders—remember the Oregon—could be properly styled *comprehensive*. However, seeing that the book is distributed gratis to merchants without the United States, there is not much room for the reader to complain.

Our New York contemporary, the *American Shipbuilder*, has come out in a new dress of type and attractive make-up. Its paragraphs of "New York Marine News" are a feature of the paper and are very interesting, and as publication is made weekly they are up to date. The proprietors, Bradley & Howell, are now making a specialty of marine photographs for sale.

On the anniversary of the blowing up of the U. S. S. Maine in Havana harbor, February 15, the keel of the new battleship Maine was laid at Cramp's Shipyard in Philadelphia, Pa.

A deal is reported from San Francisco by which the Santa Fe R.R. Co. and the North German Lloyd S.S. Co. will co-operate in establishing a line of steamships from there to ports in the Far East when the extension of the Santa Fe road to San Francisco shall have been completed.

Wrecking operations on the Spanish cruiser Reina Mercedes, begun since the close of the war, have been so far successful that it is probable that this vessel will be able to sail for the United States under her own steam. It will be remembered that she was sunk by the Spaniards with a view to blocking the entrance to the harbor at Santiago.

TRADE PUBLICATIONS.

Two folders are at hand from the Roe Stephens Mfg. Co., Detroit, Mich. One is devoted to check, globe and angle valves, the other to throttle valves. Each folder contains several illustrations, and the several valves are fully described.

"The latest and best thing in patent sheaves, being the successful application of the ball-bearing principle," is the brief statement which will attract attention on handy desk blotters sent to all who wish them by Wilcox, Crittenden & Co., Middletown, Conn.

"A New Engine Motion" is the title to a catalogue neatly printed in two colors and ready for distribution by the Parsons Engine Co., Wilmington, Del. The engine is of the reciprocating type, but has peculiar characteristics of its own. The whole device is thoroughly illustrated.

"Graphite" is the title to a four-page publication sent gratis to all inquirers by the Joseph Dixon Crucible Co., Jersey City, N. J. The object of the publication is not to boom any special business, but to attract attention to the many uses for graphite, for lubrication, paint and other purposes.

"Learn to Draw" is the title to an eight-page circular issued by the International Correspondence Schools, P. O. Box 1111, Scranton, Pa. It describes in much detail the school of drawing in connection with this institution, and includes all lines of mechanical drawing such as marine engineers would be interested in.

The McClure oil pump for cylinder lubrication is illustrated and described in a catalogue issued by the McClure Oil Pump Co., Detroit, Mich. It is the invention of an engineer of years of experience on the Great Lakes and will interest all of our readers. The catalogue is pocket size and gives quite a complete description of this pump.

A finely illustrated catalogue bound in heavy red paper and printed in gilt is received from Loring Coes & Co., Worcester, Mass., giving much valuable information regarding the machine knives and the pyrocalcic hardening process of this company. The catalogue is very fully illustrated, several pages being devoted to a department of custom hardening.

Multipolar dynamos and motors are handsomely illustrated and completely described with sectional views, special attachments, etc., in a 32-page bulletin issued by the C & C Electric Co., 143 Liberty street, New York. Accompanying the illustrations are many tables, and there is much other descriptive matter, making the bulletin of much value to anybody interested.

Packings manufactured by the Boston Belting Co., 256 Devonshire street, Boston, Mass., are thoroughly told about and depicted in a 36-page pocket-size catalogue just received. It is printed in two colors on an excellent quality of paper, making the catalogue attractive, and as the subjects include packings, valves, gaskets and diaphragms, all of our readers will want to send for a copy.

"The Westinghouse Standard Engine" is the title to a superb specimen of the printer's art issued by the Westinghouse Machine Co., Pittsburg, Pa. The paper is heavy and coated, and the cover is rich green printed in silver and black. The catalogue contains fifty-four pages, giving a most complete detailed description of the several types of these engines. These include very fine sectional views illustrating thoroughly the construction of the engines, and the several parts are fully illustrated, making the catalogue very complete. These engines are especially adapted to compact electric sets. Copies can be had on application.

Fairbanks-Morse Gas Engine Co., Chicago, Ill., has issued a very handsomely-printed catalogue devoted to a description of the engine and the many uses to which it is applied. It is of the stationary type, and one of the applications is of particular interest to our readers, as it refers to an air-compressor direct-connected to an engine for use in shipyards and other places where portable power is desirable.

A pocket memorandum book is sent gratis by the Sprague Electric Co., 20 Broad street, New York, to all of our readers who mention Marine Engineering. It contains calendars for the present year, also for 1900, and much valuable information regarding dynamos, motors and other electrical subjects, with holidays, weather reports, postage rates, tables of horse power, together with many pages in diary form.

The compartment system on ships is useless without effective water-tight doors. A little pamphlet regarding this subject is issued by the "Long Arm" System Co., Garfield Building, Cleveland, O., describing the application of the devices manufactured by this company, which are not untried, as the cruiser Chicago is fitted with a system of eleven doors. This little pamphlet describes in detail the operation of this system and its many uses.

The sectional water-tube boiler manufactured by the Almy Water Tube Boiler Co., Providence, R. I., is very thoroughly described and completely illustrated in a catalogue just issued. The illustrations are wood cuts of large size which show sectional views of different types and shapes of this boiler. It is a complete catalogue, and is one that should be in the hands of every user of boilers. A list of boilers supplied in the past eight years includes the names of some of the most prominent yachts and smaller size steamboats in all parts of the country.

"For Your Good and (incidentally) Our Own" is the title of a pocket-size pamphlet issued by the Montauk Multiphase Cable Co., 100 Broadway, New York. It is neatly bound with paper cover and is printed on a delicate tint of green paper in two tints of green ink. The construction of this cable is told in considerable detail and the many uses to which it is adapted for fire-alarm purposes either on board ship or in a building. It is intended to take the place of a watchman, and the cable is so constructed as to be capable of "discovering dangerous heat or incipient fire from every infinitesimal point of its length and giving warning thereof, locally and centrally," as the text states.

The January issue of the handsomely-printed and valuable set of bulletins issued by the B. F. Sturtevant Co., Jamaica Plain, Mass., is devoted to the Sturtevant eight-pole motors and generators, direct-current. This machine is shown direct-connected to an automatic single upright engine, the motors to electric fans, of which there are two illustrations, one being a special type of suspended fan designed especially by this company for ventilating vessels. Bulletin G regarding the Sturtevant generating sets was in such demand that a second edition was printed, and those of our readers who were not able to secure a copy of the former edition can now be supplied. This bulletin contains illustrations and full descriptions of eight sets, different sizes and styles. Copies of either of these bulletins can be had by applying to the company at Jamaica Plain, Mass.

Calendars Received.

From the Joseph Dixon Crucible Co., Jersey City, N. J., with a very effective lithograph in colors of a young woman in cap and gown holding a rose to an owl.

From the Ashton Valve Co., 271 Franklin street, Boston, Mass., a strong engraving of two children, "chips of the old block," one playing with a toy locomotive and the other with a toy steamboat.

Copies can probably be had from the companies by writing for them.

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BUSINESS NOTES.

BLUE-PRINTING OUTFIT.—Draughtsmen and others who do any blue-printing will be interested in the special appliances advertised elsewhere by the F. W. Emerson Mfg. Co., Rochester, N. Y.

MARINE SASH BALANCES.—A line of sash balances designed especially for yachts and vessels of any size is offered by the Pullman Sash Balance Co., Rochester, N. Y., whose advertisement is elsewhere in this issue.

FINE TOOLS.—Every user of fine tools appreciates the value of quality as well as a special adaptability to the use for which they are wanted. Among the concerns making a specialty of such tools is the L. S. Starrett Co., Athol, Mass.

A LATHE FOR REPAIR SHOP.—Nearly every steam vessel of any size needs a repair shop of greater or less capacity, and a lathe designed especially for these uses is offered by the Seneca Falls Mfg. Co., Seneca Falls, N. Y.

TUBE EXPANDERS.—Users of tube expanders will be interested in the advertisement of A. L. Henderer's Sons, as this company makes a specialty of this kind of tool. Full information regarding the various types can be had from the company at Wilmington, Del.

PORTABLE FIRE EXTINGUISHERS.—Every yacht and vessel requires fire-extinguishing apparatus, and among the portable ones is the "Stempel," which is sold by H. R. Bennett, 1217 Filbert street, Philadelphia, Pa. Full information regarding these extinguishers and their use is sent upon application.

HOLLOW STAYBOLTS.—The high quality and strength of hollow staybolt iron has led to the extensive use of the staybolts manufactured by the Falls Hollow Staybolt Co., Cuyahoga Falls, O., by marine boiler builders, locomotive manufacturers, etc. One of the recent orders of this company is for half a car load for the Pacific coast.

YACHT LIGHTING SETS.—The Bullock Electric Mfg. Co., Cincinnati, O., reports having received orders for six electrical equipments for yachts in one day recently. The machines used to fill these orders were in size 7 1-2 or 10 K. W. Readers interested in the subject of electricity can secure full informaton from the Bullock Company.

ELECTRICITY AT SPARROWS POINT.—In the renovation of the shipyard of the Maryland Steel Co., at Sparrows Point, Md., electricity was very generally made use of, and the C & C Electric Co., 143 Liberty street, New York, supplied a considerable amount of apparatus, including two large generators, ten motors of 6 horse power and one motor of 10 horse power.

POCKET SPIRIT LEVEL SENT FREE.—The Duval Metallic Packing Co., 126 Liberty street, New York, is giving out a most practical souvenir in the shape of a pocket spirit level. It is made of hard rubber, octagonal in shape, being about 4 in. long and little larger in size than a lead pencil. The advertisement is read through the bubble in the glass. These very unique souvenirs may be had upon application.

A BUSY SHIPYARD.—The Morse Iron Works has at present several large contracts on hand, some of which are of particular interest. Among them is the U. S. transport Panama now being fitted for cable-laying service among the Philippine Islands. The S.S. Berlin is being refitted and thoroughly overhauled. Her first trip will convey Secretary Alger and army officers on a trip of inspection to Cuba and Porto Rico. The lake steamer Aragon is being overhauled and fitted with new machinery, and will hereafter float in salt water in the coal service for the Chesapeake & Ohio R.R Co. The steamship Wetherill, which recently had her bow stove in, is being repaired, and the steamer Kanawha is undergoing a general overhauling. The Morse yard is at the foot of 26th street, South Brooklyn.

A Large Order for Tubes.—A large order for tubes for the Mare Island Navy Yard was recently awarded to Merchant & Co., of Philadelphia, Pa.

Valve Reseating Machine.—Almost every engineer will appreciate the value of a valve reseating machine, and will therefore be interested in the advertisement of the Leavitt Machine Co., Orange, Mass., in our advertising pages.

A New Safety Boiler.—A new type of safety boiler is being put on the market by the Mississippi Safety Boiler Co., St. Louis, Mo. The advertisement of this company refers to it briefly, and full details can be had by writing to the company.

Cushions and Upholstery.—The facilities of M. W. Fogg, 18 Fulton street, New York, have been pretty well taxed this winter to keep up with the orders for cushions and upholstery to supply the many new yachts and other steam vessels under construction. This company limits itself to cushions and upholstering work.

Armstrong Tools Sharpened Free.—The Armstrong Manufacturing Company, of Bridgeport, Conn., which manufactures a general line of water, gas and steamfitters' tools, sharpens and repairs all dies and bits of its own manufacture which may be returned to the factory by users of these tools. Of course this does not apply to tools in which the teeth are broken to any extent, as the company does not undertake to insert new teeth; although in some cases dies that lack only one or two teeth can be repaired.

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ZINC WHITE IN MARINE PAINTING.

Within a few years after the discovery of the modern process for making zinc white, the French naval authorities, after severe tests, ordered its use to the exclusion of white lead on the interior of all vessels of the French navy. Experience has confirmed its superiority for painting structures exposed to sea-air and sea-water, and the French navy as well as the French steamship companies now universally employ it, while it is also the official base for painting lighthouses and Government work on the seashore. The French Marine authorities also use it for painting galvanized iron plates, the hulls of torpedo boats, the shells of metal pontoons, etc.

That the French navy should have been earliest to adopt this practice is natural, since zinc white was first generally introduced in France. But the naval authorities of the United States, having made their own experiments with the same results, have adopted zinc white as the fixed component of all paints used either in the Navy or by the Lighthouse Establishment. The famous "White Squadron" obtained its color from zinc white, and remained white because zinc does not change color. Ten tons of American zinc white is the cruising allotment for each ship, and it is used liberally and effectively.

Similar testimony is found in the U. S. Lighthouse specifications, which require, for white, a mixture of one-fourth lead and three-fourths zinc, and for tinted paints, American zinc white and yellow ochre, with no lead. "The colored paints are wanted for outside use and are required to withstand the bleaching effects of salt water and sunlight."

The durability of zinc white is due to its chemical stability and to the large proportion of oil it carries to the painted surface. No other white pigment approaches it in this respect. It is the one white paint material that is capable of resisting salt water and salt air. Added to other materials it shields them and gives them durability.

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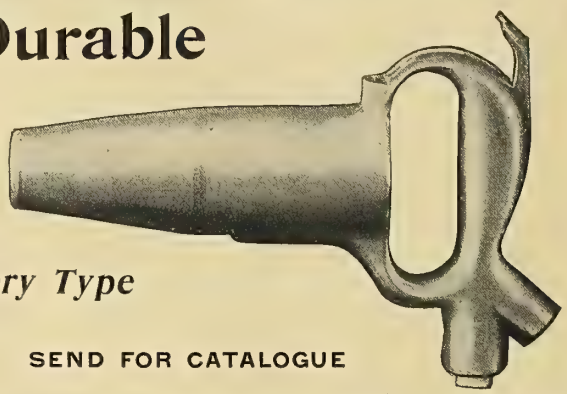

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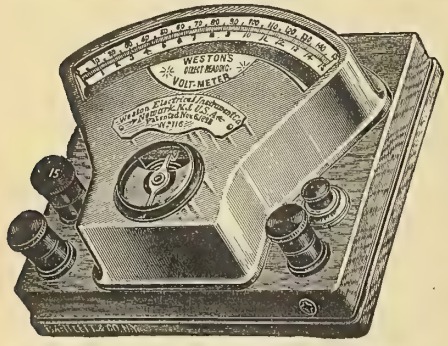

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